



Meal Elements and Lean Manufacturing: Two Frameworks for Institutional Meal Production

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Meal Elements and Lean Manufacturing:
Two frameworks for Institutional Meal Production

Ph.D. thesis

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2007

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Preface

The aim of this Ph.D. thesis is to contribute to the improvement of the quality of meals prepared in institutional foodservice.

The thesis is done in co-operation between Food Production Engineering (FPE) and the Department of Manufacturing Engineering and Management (IPL) at The Technical University of Denmark. FPE traditionally works with design and optimization of process equipment and teaches in design of food processes, while the IPL researches and teaches in general industrial processing techniques. The combination of knowledge from these two disciplines has increased the versatility of problem solutions in this work and has been a great advantage to the research. It has provided the link between technological knowledge of process equipment and management of production lines which is decisive for achieving the desired product quality in meal production.

From several case studies of Danish foodservice kitchens I was convinced that managing production lines in meal production is of great importance. Especially in large kitchens managing the lines is decisive for achieving required product quality. The conviction changed the scope of my research. I began working on this project with the primary objective to develop high quality convenience products (Meal elements) for the foodservice sector. Meal elements should substitute time-consuming processes and at the same time offer solutions to improve the eating quality of meals produced. In order to develop products with these characteristics, knowledge of meal production processes and existing product quality was needed as well as identification of actual needs for new products in the sector.

I studied several foodservice systems including cook-serve, cook-chill, large scale production at hospitals, smaller scale production at nursing homes, and

foodservice cafés but I realized soon that optimizing the quality of ingredients in meal production (by developing meal elements) was not enough. Meal quality was just as much a product of the chain of procedures in the preparation process.

From the field studies I also got the impression that the Danish foodservice sector in general is going through a change. Output quantities are increasing and production systems are becoming more efficient and industry-like as traditional cooking procedures are replaced with cook-chill systems. As a result processes need to be managed different than traditional cooking operations in order to control production parameters.

In the light of these observations the research topic changed from focusing primary on developing meal elements to also include analyses of how the performance of the very systems could be improved.

With an education in food science this meant that I had to learn a completely new discipline namely application of (industrial) production principles. Much effort was put in understanding Lean Manufacturing (Lean) principles as this production philosophy contains disciplines of high relevance to meal production. However, not all aspects of Lean were likely to be relevant in meal production and the principles needed adjustment to fit food production conditions. After three years of theoretic work the possibility for studying the practical implementation of Lean in Glostrup Hospital's Central kitchen surfaced. I was thrilled to learn that my ideas and conclusions were close to the practical application of Lean in meal production and I am grateful that Gitte Breum, Kitchen manager at Glostrup Hospital agreed on writing a manuscript "Optimization of large scale meal production using Lean Manufacturing principles" on this subject together with me. The manuscript is included in Chapter 3 and has been accepted for publishing in Journal of Foodservice.

In the spring 2007 the opportunity to test the practical application of meal elements in a foodservice kitchen appeared. Thanks to Prof. Jens Adler-Nissen a production kitchen at a nursing home in Gentofte Municipality agreed on testing the acceptability and use of meal elements in their production. Results from the study are presented in the manuscript "Meal Elements: Convenience products for the foodservice sector" in Chapter 3. The manuscript has been submitted to British Food Journal.

The two manuscripts play prominent parts in the thesis as they present the field work on the two hypotheses in the thesis. The opportunities to perform the tests came late in the research project and the inclusion of this work meant that other parts of the work were excluded from the body of the text. On this reason the initial case studies of meal production in institutional foodservice kitchens is enclosed in Appendix A. Observations from these studies supply part of the introduction to the thesis in Chapter 1.

On the same reason the paper "The modernization of hospital foodservice - findings from a longitudinal study of technology trends in Danish hospitals" is enclosed in Appendix B. The paper is part of the initial studies of existing state of procedures in large scale kitchens and has provided me with knowledge of trends and applied foodservice systems within the hospital foodservice sector. Reading the paper though is not required to understand the research project in its final form and therefore the paper is not included in the body of the text.

The decision of including the *in vivo* testings of the hypotheses changed the content of the thesis. In my opinion it is to the better as a thesis based on real-life application is more interesting to me than pure theoretic analyses.

Acknowledgment

This was my presentation of how the research found its final form but the story would have been different if I had not received great input from highly qualified people. I would especially like to thank my supervisor Associate Professor Alan Friis for great inspiration during the research. From his supervision I have learned much about the topic of the thesis but also a lot about how to communicate and act in a university environment. These are personal skills that I highly appreciate and will continue to draw on in the future.

Also, I wish to thank my co-supervisor Associate Professor Peter Jacobsen for good discussions on Lean and Professor Jens Adler-Nissen for much inspiration on the meal element part of the thesis. He also provided the possibility of testing the application of meal elements in a real environment which I consider a great contribution to and improvement of this research project.

Michael Allerup and Camilla Bitz, Herlev Hospital Central kitchen, should be recognised for allowing me to study their daily work and learn more about large scale cooking procedures. Gitte Breum and Birgitte Bonne, Glostrup Hospital Central kitchen, should also be thanked for taking their time to discuss with me the practical challenges of implementing Lean in their kitchen, and Lone Mølgård, Rygårdscentret in Hellerup, for being an enthusiastic partner in the testing of meal elements.

I would also like to thank Kirsten Skovsby at the Danish Dietetic Association for inspiration and criticism on the research and my “office-mate” Ph.D. student Johanne Rønnow Olsen for daily discussions and guidance. This has been absolutely invaluable for me and has prevented me from feeling isolated with the problems in my project. Thank you so much, Johanne!

Finally, I wish to express my greatest gratitude to my spouse Rasmus Wåhlin for his persistent support throughout this study, especially through the last - and intensive - fase of writing the thesis, and to our daughter Sesse Maj for the joy she brings.

Vedbæk, November 2007

Eva Høy Englund

This Ph.D. thesis has been carried out at BioCentrum-DTU in the period August 2003-November 2007. It is part of the project “Meal Elements optimising the quality of distributed meals” a co-operation between the IPL at DTU, The National Food Institute, and BioCentrum-DTU. The work was financially supported by The Directorate for Food, Fisheries and Agri Business.

Resume

I denne afhandling diskuteres offentlig måltidsproduktion ud fra to perspektiver: Produktkvalitet og produktionsledelse. Formålet er at afklare, om kvaliteten af måltider, produceret i disse systemer, kan blive forbedret ved hjælp af to foreslåede produktionsstrategier.

Case studier af måltidsproduktion i storkøkkener viste, at det er et generelt problem at kunne tilberede mad af høj spisekvalitet i disse køkkener. Grunden hertil kan være, at de valgte ingredienser, menuer, samt tilberednings- og distributions procedurer, ikke fungerer godt sammen (Jones and Merricks, 1997). For at lave god mad i stor skala kræves det, at ingredienser, menuer og produktions processer spiller sammen i et system og, at dette system ledes efter de rette principper. Denne sammenhæng betyder, at hvis én parameter i systemet ændres, vil det have indflydelse på de resterende parametre og dermed også på kvaliteten af de producerede måltider. Det er derfor nødvendigt at tilpasse samtlige parametre, når der foretages ændringer internt i systemet.

De problemer, der er identificeret omkring kvaliteten af mad produceret i offentlige måltidssystemer, tyder netop på, at ingredienser, menuer og ledelses systemer ikke er tilpasset hinanden i samme takt som forholdene for tilberedning og distribution af måltider er ændret.

Betydningen af ingrediensers kvalitet i forhold til spisekvaliteten af måltider bliver i denne afhandling diskuteret i forhold til Måltidselement konceptet.

Måltidselementer er halvfabrikata af høj kvalitet tilberedt industrielt til brug i specifikke retter og/eller produktionssystemer i måltidsproduktion. Eksempler på måltidselementer er varmebehandlet eller marineret kød, grøntsager og fisk samt grundsaucer. Tilberedningen af måltidselementer er tilpasset, så der kan sammensættes, opvarmes og serveres måltider på basis af elementerne ved begrænset brug af ressourcer.

Måltidselement konceptet blev afprøvet i praksis i køkkenet på et plejehjem. I forsøget blev kvaliteten og brugbarheden af for-stegt kød og for-stegte grøntsager vurderet af køkkenpersonalet med primært positivt resultat. Disse måltidselementer kunne øge udvalget af grøntsagsbaserede produkter i det pågældende køkken. Resultaterne indikerede også, at spisekvaliteten af måltider, produceret i køkkenet, kunne forbedres ved brug af for-stegte måltidselementer.

Ledelse af måltidsproduktion bliver diskuteret i forhold til anvendeligheden af Lean Manufacturing (Lean) som ledelsesværktøj. Lean er en ledelses- og rationaliserings filosofi, der stiler mod at skabe værdi for kunden i alle led i produktions- og distributionskæden. I Lean kontrolleres procesparametre nøje med det formål at reducere spild i produktionen. Præcis kontrol af procesparametre er samtidig af største betydning for kvaliteten af måltider, og derfor kan Lean vise sig at være anvendelig som ledelsesværktøj i måltidsproduktion.

Lean i måltidsproduktion blev studeret ved at følge implementeringen i centralkøkkenet på et hospital. Her viste det sig, at Lean resulterede i effektivisering af produktionen samt mere organiserede produktions- og lagerområder. Lean var også årsag til, at der blev etableret et system, hvor data på brugernes tilfredshed med maden dagligt blev indsamlet. Dette system bevirkede, at køkkenet løbende kunne tilpasse måltiderne og madens kvalitet til brugernes krav og forventninger. Case studiet viste, at Lean kunne anvendes som ledelsesprincip i måltidsproduktion og således bidrage til en forbedring af kvaliteten disse måltider.

På baggrund af resultaterne i disse cases blev det konkluderet, at både måltidselementer og Lean kan anvendes i offentlig måltidsproduktion og medføre en forbedret måltidskvalitet. Denne konklusion er dog kun baseret på resultaterne fra to cases, og for at kunne generalisere konklusionen er det

nødvendigt at udføre flere tests på anvendeligheden af både måltidselementer og Lean i måltidsproduktion.

Summary

In this thesis institutional foodservice is discussed from two perspectives: Product quality and management of production. The purposes of both being to suggest strategies to improve the quality of meals produced in institutional foodservice systems.

Case studies revealed a general problem of producing meals of attractive quality in institutional foodservice systems. A likely reason for this situation is that ingredients, meals on menus and operational systems are not well matched (Jones and Merricks, 1997). To produce meals of required quality ingredients, meals, operational system and management must work together systemwise. This means that changing one parameter influences on the performance of others and that they need to be concurrently adjusted to changes in a systematic manner.

The problems observed in institutional foodservice indicate that choice of ingredients, meals on menus, and operational management systems have not been reconsidered while conditions of meal production and distribution have changed.

Achieving required meal quality in institutional foodservice is discussed within the frame of the Meal elements concept.

Meal elements are high quality convenience products pre-prepared to be used in specified foodservice systems. Examples are meat, vegetables, fish or base sauces which are prepared by e.g. heat-treatment or marinating before distribution to kitchens. The qualities of meal elements are designed in agreement with requirements of dishes and distribution systems in use and the elements can be assembled, reheated and served with limited use of cooking operations. This framework addressed the problems observed of adjusting choice of ingredients to the operational system in use.

A case study was performed in which the quality and applicability of pre-fried meat and vegetable products was tested in the kitchen at a nursing home. The case study showed that meal elements could be applied in the kitchen and increase the variety of vegetable products served. The results also indicated that the pre-fried meal elements could improve the eating quality of meals.

The second frame applied to discuss institutional foodservice is that of applying Lean Manufacturing (Lean). Lean is a management and rationalization principle which aims at creating customer perceived value throughout production and distribution of goods. Control of process parameters is a tool to reduce non-value adding activities in Lean but is also crucial to produce required food quality. Therefore Lean may prove applicable in meal production.

A field study of the implementation of Lean in the central kitchen at a hospital showed that Lean supplied the tools needed to increase organization and efficiency of the production. Lean also caused the establishment of a feedback system on consumers' satisfaction which facilitated the process of continuously fulfilling demands on meal quality. The study showed that Lean principles and management tools could be applied in meal production and supply part of a solution to improve meal quality.

From the findings of the cases it was concluded that both meal elements and Lean can be applied in institutional foodservice and lead to improved quality of meals. However, as this conclusion is made from only two field studies more research is needed to generalize on the applicability of both meal elements and Lean in institutional foodservice.

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Outline of the thesis

This thesis is divided into five chapters and two appendices.

The first chapter is an introduction to the background of the research topic and the two hypotheses of the thesis. It includes also the methodology of the work presented in the thesis.

In the second chapter an introduction to foodservice systems and management is provided as well as the Meal elements concept. Chapter 2 also includes the theory on Lean Manufacturing as applied in the thesis.

The third chapter presents the two manuscripts included in the body of the text: The Lean manuscript and the Meal elements manuscript. These manuscripts describe the practical testings of the two hypotheses put forward.

Chapter 4 is the presentation and discussion of findings in the tests and

Chapter 5 contains the conclusions and perspectives of the work.

Appendix A contains the case studies of institutional foodservice systems and

Appendix B contains the paper “The modernization of hospital food service – findings from a longitudinal study of technology trends in Danish hospitals”.

List of manuscripts

This thesis includes three manuscripts referred to in the text by their short names.

A. The modernization of hospital food service - findings from a longitudinal study of technology trends in Danish hospitals

Eva Høy Engelund, Anne Lassen, and Bent Egberg Mikkelsen

Nutrition & Food Science (2007) 37(2), 90-99

Short name: Technology trends paper

Appendix B

B. Optimization of large scale food production using Lean Manufacturing principles

Eva Høy Engelund, Gitte Breum, and Alan Friis

Journal of Foodservice. Accepted

Short name: Lean manuscript

Chapter 3

C. Meal Elements – Convenience products for the foodservice sector

Eva Høy Engelund, Lise Schultz, Jens Adler-Nissen, and Alan Friis

British Food Journal. Submitted (in review)

Short name: Meal elements manuscript

Chapter 3

Chapter 1: Introduction

1.1 Introduction

The topic of this thesis is institutional production of foodservice meals. It discusses opportunities to improve product quality in a sector where distribution systems are changing (Technology trends, 2007) and customer demands for meals are becoming more diverse (Costa *et al.*, 2001), (Ahlgren *et al.*, 2006), (Shiu *et al.*, 2004). At the same time many processes and procedures are preserved from the traditional smaller scale cooking including choice of food ingredients, composition of meals, and cooking processes. Institutional foodservice is also a sector where product quality have been much debated in Denmark (Kondrup, 2001), (Kondrup, 2004), (Mikkelsen *et al.*, 2007), (Nielsen *et al.*, 2004) as well as internationally (Council of Europe, 2001), (Hartwell *et al.*, 2005), (Sawyer and Richards, 1994), (Watters *et al.*, 2003). In Denmark the debate has been followed by several public initiatives to improve product quality eg. Bedre mad til ældre, 2001 ("Better foods for the elderly", Ministry of Food and Ministry of Social Affairs), Bedre mad til syge, 2003 ("Better foods for patients", Ministry of Health) and Den Nationale Kosthåndbog, 2005 (The National Food Manual, www.kostforum.dk) all with the purpose to guide foodservice operators on how to improve the quality of the meals they produce.

Though attention has been drawn to the performance of institutional foodservice the literature on the management of these systems is scarce. Much more literature has been published on the impact of single processes on the quality of meal components e.g. (Aaslyng *et al.*, 2003), (Bejerholm and Aaslyng, 2003), (Byrne *et al.*, 2002), (Creed, 1995), (McErlain *et al.*, 2001), (Rocha *et al.*, 2003), and on how to increase the intake of meals prepared in institutional foodservice (Edwards and Nash, 1999), (Hartwell *et al.*, 2006), (Hartwell and Edwards, 2001), (Hartwell and Edwards, 2003), (Watters *et al.*, 2003), (Wright *et al.*, 2006), (Beck and Ovesen, 2003). Both approaches are important to foodservice systems' performance and the latter especially addresses the serious problem of undernutrition among hospitalized patients

in the EU. The foodservice systems have been identified as part of this problem (Beck A.M., 2003).

In this thesis literature on management of foodservices as *systems* and on development of *ingredients for specific foodservice concepts* was requested as part of the framework for the research.

Meal production is a system where the subsystems need to work together to produce the required output (Khan, 1991), (Jones and Merricks, 1997). Therefore it is important to consider the chain of processes in production and distribution when developing ingredients or convenience products for foodservice use. However, the “systems approach” was absent in the majority of the literature found on foodservice or food production as it focused on optimizing the quality or performance of single processes within the system. Literature which took the required systems approach to food production were mainly contributions to the field of food supply chain management (Apaiah *et al.*, 2005), (Georgiadis *et al.*, 2005), (Jansen *et al.*, 2001), (Sadler and Hines, 2002), (Hunt *et al.*, 2005) or to the planning of operations within food production systems (Soman *et al.*, 2004), (Doganis *et al.*, 2006), (Houghton and Portougal, 1997), (Hvolby, 1999). This literature gave inspiration to the present thesis though the topics were found to be at distance from the practical problems of producing meals in institutional kitchens.

The limited literature on the requested topics made it necessary to base the frame for this research on experiences and observations collected during case studies of foodservice systems and on findings in unpublished research done in the FPE group, e.g. several Master theses, Bachelor projects and activities within the “Better Food” research programme in Øresund Food Network (www.oresundfood.org).

The initial characterisation of institutional foodservice is the result of personal experiences on the subject. Case studies of procedures in seven public

foodservice kitchens (three hospital kitchens, two central production units, and two kitchens at nursing homes) were part of the start-up activities in the project with the aim of establishing knowledge of state-of-the-art in production of foodservice meals. In the case studies needs and demands for new convenience products in the institutional foodservice sector were also identified.

The case studies showed some similarities regarding choice of ingredients, cooking processes and distribution systems among the kitchens but also displayed a general problem of producing required quality of meals. As these findings were decisive for the forming of the project they are outlined in the following paragraph.

1.2 Case studies on institutional foodservices

The most striking impression of meal production received from the observed kitchens was the amount of activities going on at the same time. The main reason for the high number of activities was the variety of diets prepared to satisfy customers' requirements for special treatments. The number of meals and diets caused many production tasks to proceed concurrently. Many cooking operations involved the same equipment and this caused bottlenecks to appear. Though much energy was put in the planning of production processes the occurrence of bottlenecks hindered a continuous flow of products in production. Sometimes it also caused problems of complying with the requirements for food temperature set by the kitchens' internal quality control programmes.

Another observation was a general absense of routines to control process parameters during cooking. The consequence was difficulties in achieving desired quality of meal components, especially in the large kitchens at hospitals and other central production units. A reason for this may be that the responsibility for product quality was more diffuse in these larger kitchens.

In processes where cooking parameters were actively measured during production this was not done to optimize the quality of the meals produced, was merely a question of complying with the internal quality control programmes. Heat-treatment, as an example, was often extended further than what was needed to cook products. During these processes the requirements for product temperature set by the quality control programmes were perceived as minimum requirements and any product temperature above this would be acceptable. The procedure did not include any considerations of product quality and was especially an issue when foodservice systems involved chilling and reheating of products before serving.

Cooking processes and equipment were often designed to smaller scale production and were not optimal when output increased. As an example, the frying of meat and fish in portion sizes involved filling up the frying table to maximum. This procedure made it difficult to control the state of cooking of the single piece of product and had a negative influence on product quality.

It was also noticed that the operational systems of meal production were often cook-chill systems especially in larger production units and that these systems were increasingly applied at the expense of traditional cook-serve procedures. In these systems meals are cooked, portioned and chilled at a central production unit before distribution, finishing and reheating in satellite kitchens. Cook-chill at hospitals and nursing homes was mainly seen as a method to reduce costs of production and decrease the time pressure during production but the use of cook-chill also had other purposes. At a nursing home cook-chill production was used as a mean to involve the residents in the cooking of their own meals. Main meal components were cooked and chilled in the central kitchen, distributed to satellite kitchens and finished by the residents as part of their daily activities. Another use of cook-chill was seen in a hospital kitchen where meals were cooked, chilled and stored before reheating and serving the following day. In this kitchen cook-chill was used as a safety net allowing

enough time for re-doing meal production if the cooking eventually should go wrong.

In larger systems, cook-chill as well as cook-serve, the production and the distribution of meals were considered two separate systems. Different groups of personnel were responsible for the two systems and this made coordination of activities difficult. As a result, distribution was sometimes delayed and systematic collection of feedback from consumers to kitchens on meal quality hindered. The division of production and distribution made it difficult to continuously adjust meal quality to customers' demands.

1.2.1 Findings from the case studies

From these observations I found that two common conditions in the kitchens were highly influencing the quality of foodservice products;

1. Lacking control with process parameters during cooking of meals or meal components, and
2. Inadequate planning of production processes combined with little integration of distribution and production into one system

The problem of controlling process parameters during cooking seemed mainly a result of the many tasks performed simultaneously in the kitchens. The high number of processes going on made it difficult to coordinate activities and control processing parameters during meal preparation. The effect of this was enhanced by the design of equipment and choice of processes which seemed little coordinated with changing scale of output. Conditions like these will have an effect on meal quality as food quality is much dependent on cooking time and temperature (Rodgers, 2005).

Insufficient planning of production processes made bottlenecks occur in production and made it difficult to meet the temperature requirements for food during the production process. This was problematic in relation to the quality

control programmes in the individual kitchens but also contributed to the difficulties in controlling time and temperature during production.

The perception of production and distribution as two independent systems with separate management were also problematic in relation to meal quality. In cook-serve systems this resulted in little co-operation between personnel groups involved in the foodservice as the groups prioritized the meal-service part of their jobs differently.

In cook-chill systems the missing integration of production and distribution showed as over-processing of some foods and in inappropriate choice of ingredients and meals on menus. Some meal ingredients did not appear attractive when served as their colours and/or textures were much changed by the storing and re-heating processes. These ingredients or meal components were simply not matching the chosen foodservice concept. However, conditions like these were either never returned to the kitchen or not considered problematic by the kitchen staff as the observations seemed to have little influence on choice of ingredients in meals prepared. The division of production and distribution in two separate processes may be responsible for the insufficient communication between personnel groups.

1.3 Forming of hypotheses

From the case studies it was found that relevant perspectives to apply in this research on institutional foodservice was 1) the problems of achieving required product quality and 2) the problems of managing production and distribution.

In this light two frames for the research were formed and two hypotheses set forward. The theoretic backgrounds for the two frames, the Meal elements concept and Lean principles are thoroughly explained in Chapter 2. They are also briefly included in the following descriptions of the forming of the two hypotheses.

1.3.1 Hypothesis 1

Solutions to achieve improved product quality in meal production are often based on development of new technologies or on optimization of traditional processes. Production equipment designed to automatically control process parameters can reduce the practical problems of controlling food production processes and this may lead to improved food quality. Still, optimizing performance of parts of production by improving design of equipment may not change end-product quality if the subsequent processes and procedures are unchanged.

The studied kitchens seemed to have no tradition for carefully controlling cooking parameters and therefore it is a question if improving production equipment will change the quality of end-product. As an example it did not seem to matter if a pork chop was fried for 5 or 10 minutes on each side as long as it was prepared following the procedure of browning followed by approximately 20 minutes of baking until reaching a center temperature of *at least* 70°C. The procedure was defined by the individual quality control programmes and baking was rarely adjusted to fluctuations in actual frying time. Meat prepared in this process was often very well-done before entering the system of (chilling, reheating and) distribution. In a case like this improving frying equipment would not have much effect on product quality when baking remain the same.

This thesis suggests another solution, namely partly substitution of difficult controllable processes, like the frying of meat, with convenience products. The use of more convenience products in the kitchens would simplify cooking procedures and reduce the number of tasks in the kitchens. Convenience products could theoretically be of superior quality to conventionally produced meal components if produced under optimal conditions and using properly designed equipment. This is the background for the first hypothesis of this thesis.

“The quality of foodservice meals can be improved by use of meal elements”.

Meal elements are high quality convenience products developed to fit the special conditions observed in foodservice kitchens. They are partly prepared and can be assembled to a variety of meals with a minimum of cooking operations. The concept of meal elements is further presented in Chapter 2 of the thesis.

Hypothesis 1 is tested by involving foodservice professionals to evaluate the quality and applicability of a selection of pre-fried convenience products (Meal elements) prepared at BioCentrum-DTU. The case study and findings therein are presented in the manuscript “Meal elements: Convenience products for the foodservice sector” included in Chapter 3.

The concept of Meal elements provides the frame for the research done on product quality in institutional foodservice while the manuscript represents the practical work within this frame.

1.3.2 Hypothesis 2

The second hypothesis has its background in the observation that the ability to control meal quality rely on detailed management of cooking procedures. In larger production kitchens it seemed to be especially difficult to manage product quality. The cooking of large portions of meals and the associated difficulties in controlling production parameters influenced the meal quality negatively. This was especially a problem when staff did not feel any personal responsibility for product quality. Hence, systematization of procedures for controlling production parameters could lead to improved product quality.

The mean to achieve this is suggested to be an increased level of management of process lines. The purposes of managing procedures are to

establish the routines needed to control production parameters and to integrate the production and distribution of meals into one system. The latter should especially facilitate communication and flow of products which seemed to be problematic in both cook-serve and cook-chill systems. From this the second hypothesis is formulated:

“Lean Manufacturing can be applied in institutional foodservice and lead to increased meal quality”

The thesis includes a discussion of the applicability of Lean Manufacturing (Lean) principles in large scale meal production. It is also discussed if Lean principles can be applied to manage production processes and increase control of process parameters. In short, Lean is a Japanese production management concept aiming at achieving customer perceived value throughout production by eliminating all sorts of waste. Eradicating waste leads to a highly coordinated and shortened production line with little storing of raw materials and products. As time and temperature during production are crucial for the quality of foods a management principle focusing on controlling production parameters may be suitable to manage meal production. Lean principles are explained further in Chapter 2.

Hypothesis 2 is tested by studying the practical implementation of Lean in the foodservice system at a hospital. The field study and findings are presented in Chapter 3 in the manuscript “Optimization of large scale food production using Lean Manufacturing principles”. The theory of Lean provides the frame for the discussion of management of institutional foodservice and the manuscript presents the research done within this frame.

Lean has origin in mass production and every part of the principle is not equally applicable in meal production due to the special characteristics of food and food production. These considerations are included in the Lean

manuscript together with an elaborated argumentation for the choice of Lean as management principle.

1.4 Study of technology trends in hospital foodservice

Both Hypothesis 1 and 2 are based on observations from case studies on foodservice production. The changes in choice of operational systems and logistics during serving in the Danish hospital foodservice sector have also been explored through data analyses. The results are presented in the paper “The modernization of hospital food service: findings from a longitudinal study of technology trends in Danish hospitals” enclosed in Appendix B.

In Figure 1 the relation between observations in case studies of institutional foodservice, problems observed, hypotheses, literature and manuscripts is illustrated to further clarify the structure of the thesis.

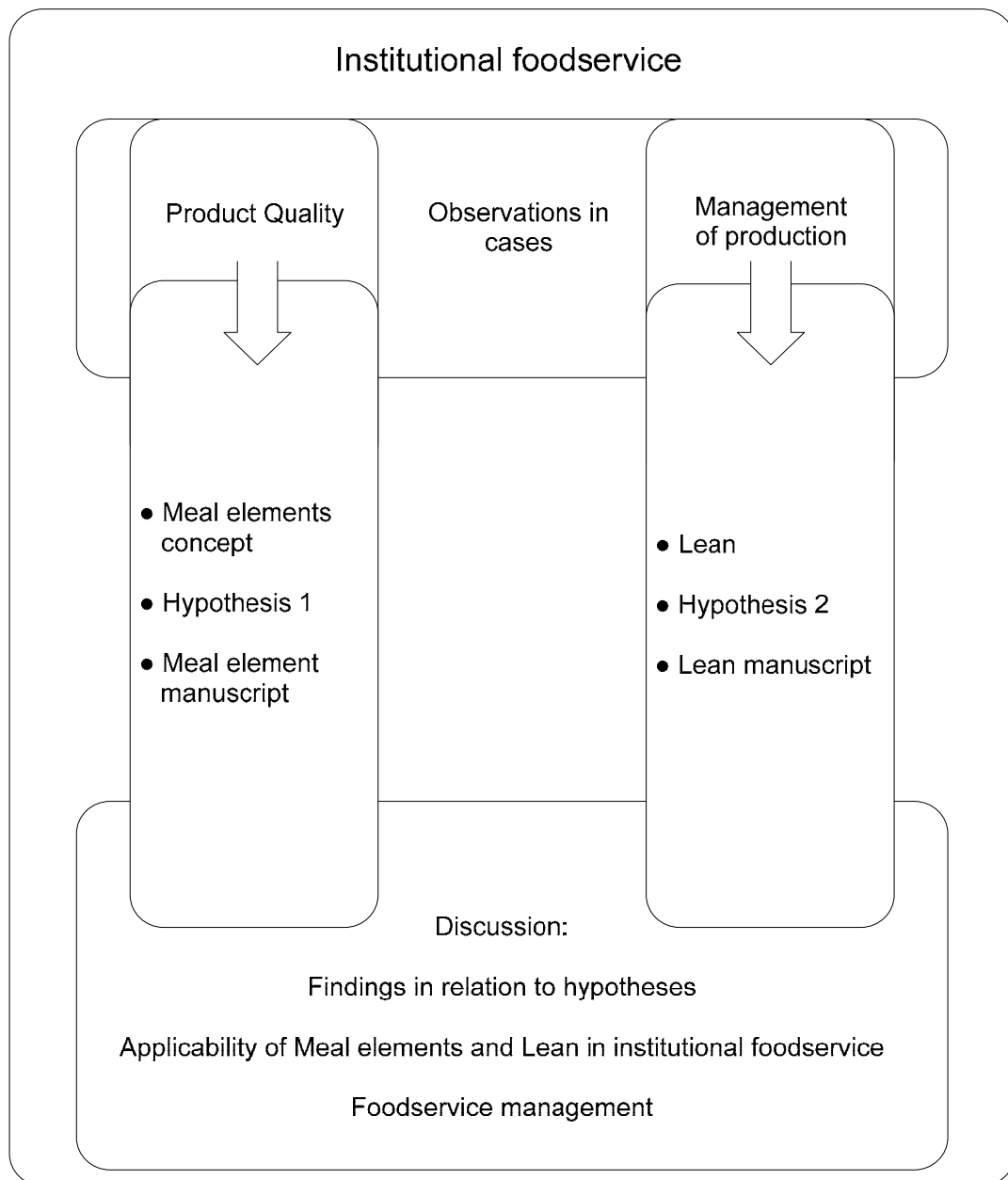


Figure 1: Structure of the thesis

1.5 Hypotheses

This Ph.D. project explores the opportunities to improve the quality of foodservice meals by taking two approaches. The first is based on the argument that there is a general need for high quality convenience products which quickly and with limited use of cooking equipment can be assembled to culinary attractive meals in the foodservice sector.

Hypothesis 1:

“The quality of foodservice meals can be improved by use of meal elements”

Meal elements are partially prepared ingredients stabilized by cooling or in some cases by freezing for a given short period of time. The elements can be assembled and reheated and still give the impression of a meal prepared of fresh ingredients.

The second approach concerns the need for reviewing organization and procedures of meal production. It is a discussion of the applicability of an industrial production principle (Lean) in meal production.

Hypothesis 2:

“Lean Manufacturing can be applied in institutional foodservice and lead to increased product quality”

In the thesis Lean is discussed as a tool to achieve increased control of process parameters in order to improve the quality of meals produced.

1.6 Methodology

In this thesis different research methodologies have been applied. These are outlined in the following.

1.6.1 Case studies of foodservice procedures

The observations of production procedures in seven public foodservice kitchens were resulting from seven case studies. The methods applied during these studies are included in the case studies enclosed in Appendix A.

1.6.2 Study of technology trends in hospital foodservice

The methods applied to collect and analyse data in the study of hospital foodservice systems are presented in the Technology trends paper in Appendix B.

1.6.3 Testing of meal elements in a foodservice kitchen

The methods applied in the preparation and testing of meal elements are described in the meal element manuscript in Chapter 3. The case study involved observations of production processes in the kitchen and identification of which meal elements to prepare in pilot plant. The observations followed the same method as the seven case studies of foodservice kitchens included in Appendix A.

1.6.4 Field study of Lean in a hospital kitchen

The field study of the application of Lean in the hospital kitchen at Glostrup Hospital and the method applied to collect data is described in the Lean manuscript in Chapter 3.

Chapter 2: Theory

2.1 Foodservice management

This text is a brief introduction to foodservice systems and the management of these. It is not the purpose to supply a detailed description and discussion of how to manage foodservice production but merely to provide the general understanding that foodservices must be considered as systems in contradiction to as individual procedures.

The first paragraph is an introduction to common foodservice systems. The second paragraph presents the principal features found in the literature on foodservice management and the third paragraph explains the application of the theory in the thesis.

Litterature on foodservice management is very scarce but still found to supply a good overview of the topic.

2.1.1 Foodservice operations

The basic concepts of food production systems are illustrated in Figure 2.

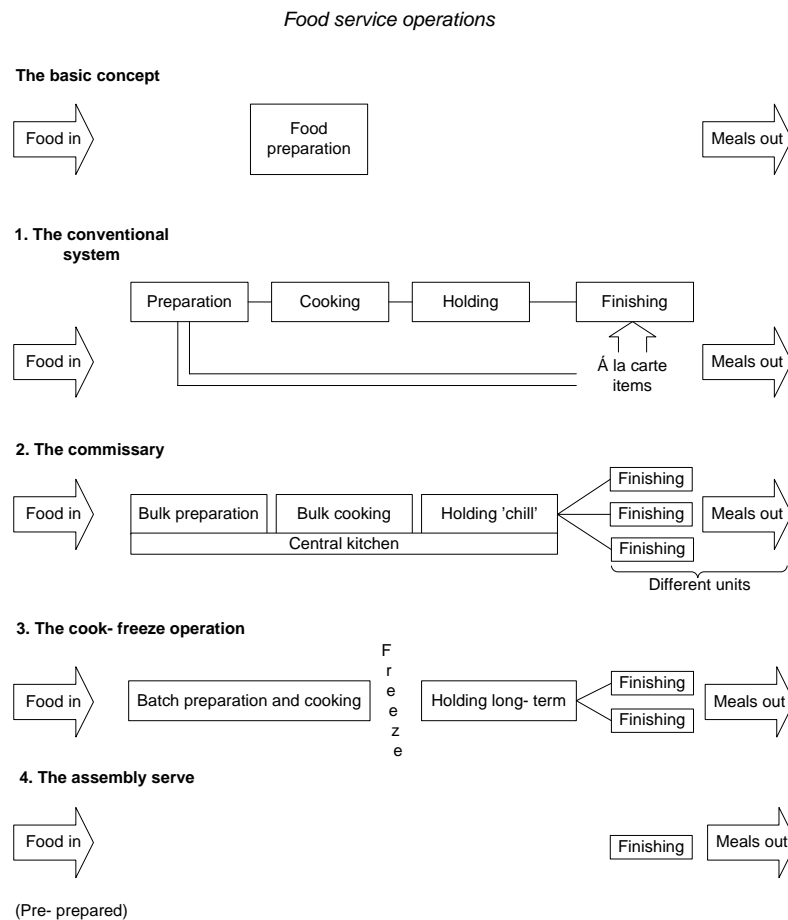


Figure 2. Food production systems from Jones and Merricks, 1997

The “cook-serve” system in institutional foodservice has most similarities with the conventional system often applied in restaurants (Figure 2 No. 1). Only the holding time can be considerably longer in institutional systems. Meal components are prepared, cooked and held warm before assembling and serving of meals. Food can be distributed warm as plated meals or as bulk to be plated before serving. The time gap between production and consumption depend on the logistics of the system; the distance between cooking unit and point of serve and the number of people and procedures involved in the system.

The commissary system in Figure 2 resembles “cook-chill” production of meals. The system is based on bulk cooking of meal components in a central production unit and finishing of meals in satellite kitchens. The components

are packed in suitable portions and held cold (chilled) before distribution to the satellite kitchens. The finishing needed is limited to reheating, assembling and serving of meals and satellite kitchens need only have a limited choice of cooking equipment. The holding time depends on the planning in the single kitchen but the products can have a shelf life of up to three weeks if heating, chilling and packing procedures are performed correctly.

The “cook-freeze” operation (No. 3 in Figure 2) is much similar to the cook-chill system only food is frozen hence holding time may be longer.

The assembly-serve system (No. 4) is the system applied in satellite kitchens where pre-prepared meals or meal components are received from a central production unit and finished before serving. It is similar to the finishing procedure in the cook-chill system illustrated in No.2.

2.1.2 Managing foodservice operations

The general systems described above comprise inputs, processes and outputs. The performance of foodservice systems is a result of two main disciplines: 1) the planning and design of the specific concept and 2) the ability to manage the foodservice operation (Jones and Merricks, 1997). Planning and designing a concept includes choice of inputs (raw or processed ingredients), processes (preparation, cooking and serving) and type of meals served e.g. French *gourmet* style, family restaurant style or fast food. In foodservice output quality is as perceived by the customer and influenced by his or hers overall experience of the subsystems (ordering, receiving and eating the meal if on location) of the foodservice. The quality of meals is only one - though important - parameter in the perception of the foodservice and all subsystems must work well together to deliver the expected quality of output.

The concept must be designed to fit the special needs of its clients e.g. fastfood customers, hospital patients or elderly people living at nursing homes all have different requirements for service level, meals on menus and eating quality of components etc. To ensure that output quality meets clients'

requirements systematic feedback from users is necessary to include in the performance assessment of the foodservice system (Khan, 1991), (Jones and Merricks, 1997).

Management of subsystems (organizing, staffing, directing, controlling, budgeting, developing, marketing, planning, communicating and decision making) is necessary to make them work together and essential to a foodservice system's performance (Khan, 1991). The objectives of the subsystems may differ between institutional versus commercial foodservice, e.g. marketing of hospital foods has the goal of increasing the patients' intake of calories to prevent undernutrition whereas marketing of foods in a commercial foodservice facility should increase the owner's profit through increased market share or gross margin on the product. However, this applies also internal in institutional systems where differences in organization of subsystems e.g. distribution and serving impede a well working system. A major reason for this is that institutional foodservice traditionally is a complementary service offered to patients, students, employees, or residents (Khan, 1991).

Jones and Merricks have identified three basic reasons why foodservice concepts perform badly.

1. Application of an improper concept in a specific context
2. The operational system does not fit the concept
3. Management does not meet the standards of performance expected

An improper foodservice concept refers to the situation where clients do not understand the idea of the foodservice concept. In commercial foodservice this is as an example the situation where (international) food chains fail to be successful in a new setting where users of foodservices have food or setting preferences which differ from those included in the concept. In institutional

foodservice an improper concept could be buffet-style serving of Mediterranean food at an elderly home where the residents may walk with difficulties and expect to be served a meal consisting of meat, potatoes and sauce. The success of the buffet concept is little likely in this context.

The operational system does not fit the concept if it fails to deliver the expected quality of food. In the example with the Mediterranean buffet this could be a cook-chill system incapable of delivering fresh tomato salads, grilled fish and the like.

Poor management is the third reason for foodservice systems failing to perform as expected. The important subsystems included in the management of foodservice operations have been listed above and there are an unlimited number of reasons why management can fail to reach expectations. It can also be expressed in a single sentence by stating that successful management of foodservice systems should combine inputs and processes in an efficient way to effectively produce required output (Jones and Merricks, 1997).

Jones and Merricks further suggest that the wide criticism of hospital food results from the quality of meals produced in systems where the operational systems and concepts do not march. They further comment that poor management is often singled out as the reason for the failure of these systems to deliver meal quality as expected.

2.1.3 The use of foodservice management theory in this thesis

The theory on foodservice management is part of the discussions of the testing of the two hypotheses in Chapter 4. It also forms the basis for the final discussion of how the two frameworks of the thesis “Meal elements” and “Lean” can be applied in the design of foodservice concepts and if they can contribute to the improvement of foodservice meal quality.

2.2 The Meal elements concept

In this paragraph the concept of meal elements is presented. The concept supplies the frame for the discussion of ingredient and end-product quality in institutional foodservices and is part of the background for Hypothesis 1. The concept is discussed in relation to foodservice management in Chapter 4.

2.2.1 Introduction and background

The number of meals consumed outside the home is on the rise (Rodgers, 2005), (Shiu *et al.*, 2004), (Edwards and Nash, 1999). Some years ago in Denmark most everyday users of catering meals were residents at hospitals or elderly homes. Now captive catering includes daycare centers, schools, and workplace canteens. Meals served at these locations and to an increasing degree at hospital wards are typically finished in satellite kitchens (Technology trends paper). This implies that components are prepared at a central unit and distributed to small kitchens (satellites) where staff assemble and/or reheat (parts of) the meals before serving. Satellite kitchens have little production equipment and only simple cooking operations can be done in these settings, e.g. microwave heating.

To distribute high quality meals from such units meal components of a homogenous and robust quality are demanded. This is necessary to simplify final processing and to minimize the impact of chilling, distributing and reheating procedures on the quality of end-products.

Production of meal components of the required quality demands exact control with production parameters during preparation and the use of highly professional equipment. Equipment like this is seldom found in foodservice kitchens hence these products can rarely be produced. Instead, the production must be centralized in production units where adequate equipment is located.

From the above the need for a new kind of industrially prepared convenience products for the foodservice sector is identified. The products must fulfill the

requirements for ingredient quality set by the operational systems of typical foodservice systems (Jones and Merricks, 1997). It means that they must be easy to handle to minimize the time needed to assemble meals from the elements; they must be of a homogenous quality to allow simple reheating procedures; they must be flexible to increase diversity of use, and they must be of a stable quality to minimize product waste. But most important the eating quality of meal elements must be superior to conventional convenience products in order to improve the quality of meals prepared.

In order to clarify these requirements further the concept of Meal elements¹ has been developed. The concept describes a frame of product attributes to strive for when preparing convenience products for the foodservice sector. The concept is presented below.

2.2.2 Meal Elements – the concept

Meal elements are partially prepared ingredients, stabilized by cooling or in some cases by freezing for a given short period of time. Typical examples are pre-prepared meat, vegetables, fish or base sauces which are prepared, e.g. by heat treatment or marinating, before distribution to users (kitchens or catering outlets).

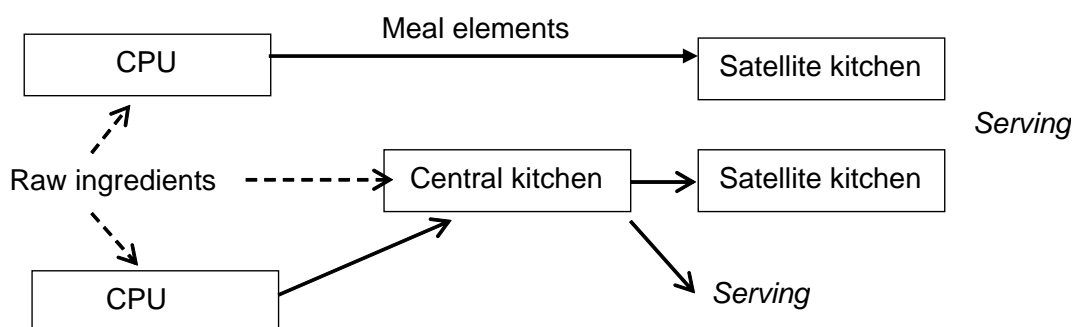


Figure 3: Production and distribution of meal elements

¹ The concept of Meal Elements is developed by Professor Jens Adler-Nissen, Associate professor Alan Friis and Cand.Techn.al. Johanne Rønnow Olsen from original idea by Jens Adler-Nissen. Food Process Engineering, BioCentrum-DTU.

The elements can be assembled and reheated without much processing and still give the impression of a meal prepared of fresh ingredients. Meal elements are produced centrally in the industry or at other (central) production units (CPU) where adequate equipment to produce large output quantities of required quality exists. Following production, packing and chilling the elements are distributed to central kitchens for further processing and/or assembling to meals or to satellite kitchens as ingredients in ready-to-eat or re-heat meals (Figure 3).

Meal elements should substitute conventional produced products in foodservice kitchens. This implies that the majority of resources allocated to the production tasks can be relocated in production. In the meal elements concept resources are transferred to other tasks which have shown to influence on end-product quality and which have not been prioritized during the conventional procedures. Examples are garnishing of dishes with herbs, developing of new recipes which increase variety of dishes served, or to have kitchen staff present the meals to clients. The aim of this is to optimize the allocation of resources in production and improve client perceived quality of meals.

In the concept foodservice meal production is considered a system in which resources can be re-allocated in order to increase product quality. The systemwise approach is also applied in the determination of product quality. Initial preparation of meal elements must be in agreement with requirements set by the following procedures to achieve the highest possible end-product quality. The quality of meal elements is described in the next paragraph.

2.2.3 Quality of meal elements

The preparation of meal elements must differ with the type of raw ingredients *and* in agreement with the requirements for end-product characteristics. This means that they must be prepared to be used in a specific type of dishes, e.g. vegetables should be less heat different when prepared for use in Asian dishes than for use in traditional European dishes. It also implies that several

qualities of the same type of ingredient must be produced. This variety in product quality is in contrast to the uniform quality of existing convenience products and an important feature of meal elements.

Example: Existing convenience carrot products are either raw or frozen (with softened texture) and there is no alternative to these qualities. The characteristics of these products limit the applicability of the carrots as they are suitable ingredient in only some types of meals or complex products. Carrots produced following the meal elements concept should supply a new kind of product with quality as defined by the specific use of the carrots, e.g. crispy carrot products ready to re-heat and serve or to use as fillings in complex products.

The quality of meal elements should fill out the gap between raw ingredients and that of conventional convenience products as the preparation is tailor-made to a specific use. This means that the end-product decides the quality of the meal elements in contrast to the existing situation where ingredients have a fixed quality which will influence end-product's quality. The theoretic result is that end-product quality is improved.

To produce meal elements of required quality it is necessary to carefully adjust the initial preparation of the meal elements to the subsequent processes. This is important to retain differences in product qualities and implies that preparation of meal elements is considered one step in a *line* of procedures which all influence on end-product quality. The chain perspective on production procedures is central to what differentiates meal elements from conventional convenience products.

2.2.4 Application of meal elements

Application of meal elements can follow two scenarios:

- 1) Ingredients in meals assembled and reheated in satellite kitchens
- 2) Ingredients in meals prepared in central kitchens.

In both scenarios the aim is to improve the quality of meals prepared compared to that of meals prepared from conventional products. The conditions of the use and the following requirements for meal elements quality are outlined in the following.

Meal elements in satellite kitchens

In satellite kitchens meal elements are assembled and reheated immediately before serving with use of simple cooking operations. The amount of time available is limited as the customer often waits for the take-away meal. To be able to serve a variety of meals within the given short time meal components must be easy to handle and mixable. To further facilitate the finishing procedure the elements must be prepared to a degree where reheating can be done in a single process without causing deterioration of the eating quality of components.

Meal elements in conventional foodservice kitchens

In foodservice kitchens meal elements can substitute traditionally prepared meal components. Processes to be considered for substitution are

- A) Processes from which desired product quality is not achieved
- B) Time consuming processes

Re A) Meal elements are produced using advanced production equipment and during strict control of production parameters. This implies that the quality of meal elements in general will be superior to that of conventional prepared products when conventional processes do not allow such control of production parameters. From this it follows that meal quality will be improved by substituting conventional products with meal elements.

Re B) Time used on tedious or time demanding tasks can be reduced by use of meal elements. This is in agreement with the common application of

convenience products as these are used to reduce the need for resources (time and staff) in foodservice kitchens. However, in the meal elements concept the idea is to transfer these resources to the more gastronomic parts of meal processing. In this way end-product quality is improved by redistribution of resources.

In summary the application of meal elements can theoretically improve the quality of meals produced in two ways: Improvement of ingredient quality and/or reallocation of resources to enhance overall product quality. However, the application of meal elements also brings the possibility to increase variety of food products served without increasing the time needed to prepare raw ingredients. This is a third way to improve the quality of the foodservice.

Meal elements; the example of fried meat

A conventional product which could be replaced by meal elements and improve product quality is fried meat. Standard production procedures in large scale kitchens include surface browning at a frying table followed by heat treatment in ovens (baking) to finish products. The frying can take several hours, depending on product amount. At the same time it is a difficult process to perform, especially in large scale. During frying of meat water exudes and turns frying into boiling if not evaporated quickly. The evaporation of water depends on the products' temperature and the proportion of product amount to the frying surface. However, the general frying procedure in the average kitchen (filling up the frying table) prevents sufficient evaporation but is followed to reduce the time allocated to the process. As a result the meat is boiled rather than fried and homogenous product quality is difficult to obtain. Hence, frying of meat takes up much time in foodservice production and the resulting quality of products is not as required. In order to prepare fried meat of required quality using conventional equipment prolonged production time is required.

Another solution is to fry meat in central production units with the use of advanced frying equipment which can produce the required product quality without time-demanding procedures. The pre-fried meat must be distributed to the kitchen for finishing or further distribution.

The use of pre-fried meat would in this example impact on meal production in two ways: The meal elements would be of improved quality to traditionally prepared meat, as boiling would be avoided, and ressources allocated to the frying procedure could be transferred to other processes in the kitchen found to be important for perceived customer value of products. Thus application of meal elements could theoretically lead to improved meal quality.

2.2.5 Advantages and limitations of the meal elements concept

From the concept of meal elements it follows that application of these products in conventional foodservice kitchens or satellite kitchens can result in improved meal quality and lead to optimized use of ressources in production. Hence, the theoretic advantages of applying meal elements go beyond improvement of product quality. It also includes a possibility to improve the performance of foodservice systems.

In both satellite and central foodservice kitchens the use of meal elements can increase variety of dishes served. The elements can be combined as modules provided that you have a large selection of meal elements at your disposal. Elements need only require the same reheating process to “fit” together as parts of a dish. This increases flexibility at serving point and clients’ choice of meals.

There are several limitations to the concept, the first being of course that only few convenience products of the defined “meal element-quality” exist on market. The concept is *theory* which also means that foodservice professionals have not been presented for the concept or been given opportunity to influence on important aspects of the concept, e.g. requirements for meal element characteristics.

Another question of high importance is that of economy. The concept does not consider that the costs of meal elements are higher than that of raw ingredients. It is a basic assumption that resources can be reallocated in production without effect on overall production costs. However, when processes are substituted by meal elements all resources cannot be re-allocated without increasing overall costs of production. To keep costs neutral the costs of some resources need to be cut. Hence, there is a possibility that meal elements can be applied to rationalise meal production.

The concept fails to notice this aspect by focusing only on the quality of meals produced. It is though, a very important for the acceptance and applicability of the concept in foodservice kitchens.

2.2.6 The use of the Meal element concept in this thesis

In this thesis the concept is presented for foodservice professionals in a test kitchen with the purpose of observing the acceptability and applicability of meal elements in a foodservice kitchen. The findings from the test are included in the Meal elements manuscript in Chapter 3. In Chapter 4 the findings are discussed in relation to the concept and then the applicability of the Meal elements concept in institutional foodservice systems is discussed.

2.3 Lean Manufacturing

In this paragraph Lean is described. The aims are to introduce readers who are not already acquainted with Lean as a management and rationalization principle to the characteristics of a Lean production setting and to explain relevant Lean tools provided to increase efficiency of production.

2.3.1 Introduction

Lean is a production concept first coined in 1990 by Womack, Jones and Roos in the book “The Machine That Changed The World”. The book was the outcome of a 5-year research project of car production systems. The background for the interest in car production was that the American car industry was losing market shares to the Japanese in the 1970s and 1980s. The researchers concluded that while the American industry was based on mass production principles new techniques and management principles were widespread among the Japanese car factories. The authors found Toyota’s car production (Toyota Production System, TPS) superior to western production systems and described it as “Lean” to reflect how trimmed and competitive they saw the production system (Michelsen, 2005).

In 1996 Womack and Jones wrote a follow-up on “The Machine That Changed The World” called “Lean Thinking” and in 2003 this was revised and published with the subtitle “Banish waste and create wealth in your corporation” (Womack and Jones, 2003). This subtitle refers to the efficiency observed in the Japanese car factories and to the authors’ conviction that a flowing production line with a limited number of wasteful procedures will cut down costs of production and increase the competitiveness of a company. In the books the authors state that a Lean process can be achieved by incorporating a set of principles in existing operations. They further claim that understanding the production philosophy is paramount for success as Lean is not a time-limited project but a continuous process of improving production line and

product quality in the strive to increase customers' satisfaction. Therefore Lean must be an integrated part of daily routines.

In the following, Lean principles and some tools and techniques important for the understanding of the further work, are explained.

2.3.2 The five basic production principles

Lean manufacturing aims at creating value for the consumer throughout the entire production line. *Value* in this term is characteristics that make the product or service more valuable to the end customer. The contrast to value is waste (*muda*) which is seen as any activities that absorbs resources but creates no value (Wood, 2004). Activities like these must be avoided as they reduce efficiency and increase costs of production (Womack and Jones, 2003). To identify and eliminate waste in production Womack and Jones have summarized the essence of Lean into five principles. These principles are explained singlewise but they work together systemwise in a Lean setting. The process is summarised below:

The critical starting point in a Lean process is determination of *value* from the customer's point of view. Every activity throughout the production should add specified customer value to the product. The definition on this value is that customers are willing to pay for the characteristics. Non value-adding activities are *waste* and must be minimized or eliminated in time.

Having identified value of products the next step is to identify the value stream in the production line. To do this an overview of procedures is needed and this can be obtained by using the Lean tool "value stream mapping". Value stream mapping refers to the mapping of a products route through the setting and identification of processes which increase customer perceived value of products. It is briefly explained later in the paragraph.

The third principle is the connection of value creating activities in a continuous process flow. Every bottleneck or "batch and queue" process must be avoided to obtain uninterrupted flow through out production. The "ideal" situation is

drawn on a map, and the actual procedures are changed and equipment relocated to reflect this. To improve the flow of value creating activities it may be necessary to renew equipment and production utensils as inadequate working processes are categorized as waste.

The fourth principle is to let the customer pull the product. This means that nothing is produced upstream unless it is needed downstream. This principle is in contrast to batch and queue procedures, as seen in mass production, and pull production aims at reducing the resources locked up in inventories. It implies that production must be just-in-time both internal between processes and external when delivering products to the customer.

The fifth principle is about pursuing perfection through continuous improvement. This is not only about creating the product that the customer requires with a minimum of defects but also includes the perfection of every action in connection with the production process. This involves all employees as they know procedures best and are closest to bringing up suggestions for improvement. The involvement of everyone in the continuous improvement is what makes Lean a philosophy – improving working processes is integrated in job routines (Bicheno, 2004), (Womack and Jones, 2003).

2.3.3 Lean tools to prevent waste and wasteful activities

The tenet of Lean is elimination of waste and wasteful activities as the mean to increase efficiency of production line (Simons and Zokaei, 2006). Absence of procedures categorized as waste is needed to achieve value in all links of the chain of production processes, but actually Lean as a philosophy is about *preventing* waste more than *eliminating* it (Wood, 2004). In Lean, tools to organize staff, procedures and materials in production are supplied to support the process of reducing wasteful activities. The following text is a specification of what is seen as “waste” and a presentation of some of the Lean tools found to be relevant in the present research.

Waste and wasteful activities

To be able to prevent waste in a process one must understand the different types of activities in production that can be assigned to this category.

Originally seven types of waste were identified (Womack and Jones, 2003):

Waste from waiting, waste from transporting, waste from overproduction, waste from defects (rework products, paperwork errors and mistakes), waste from unnecessary motion (moving of people), waste from inventories (overstocking), and finally waste from unnecessary processing (packaging, wrong equipment for job). Later, two more types of waste have been added: Design of goods and services, which do not meet customer's needs, and untapped human potential.

Value stream mapping

In production value stream mapping refers to the identification and mapping of the processing of a good or a group of goods. It is one of the initial tools applied to get an overview of existing production and activities therein as it ideally reveals all procedures from product design to production and distribution of end product. The mapping (a real map is drawn) shows the location of production equipment in use and from the map, a product's "route" through production site is visualized. With the customers' requirements for product's characteristics in mind the map is used to characterize activities as "value-creating" or "non value-creating". Value stream mapping is the tool used to identify non value-creating activities which must be eliminated in order to obtain an efficient and customer oriented production line consisting of value-creating activities.

5S

Increased organization of raw materials and utensils are another Lean tool to prevent wasteful activities during production. The "housekeeping" tool "5S" supplies a set of practices which results in increased organization of production when incorporated in the daily routines. The 5S's stand for: Sort

(equipment, remove what is not used), Simplify (equipments and tools must be in the right place), Sweep (tidiness but also routine checking of equipment for defects), Standardise (working procedures), and Sustain (the housekeeping is an ongoing procedure. Implementation of 5S in theory leads to a reduction in time wasted on non value-adding activities e.g. reduces time used to locate tools or raw materials needed in production. This will increase time available for value-adding activities which means that production becomes more efficient.

Improvement of processes: Kaizen and Kaizen Blitz

In the first section of this chapter Lean was described as an ongoing process involving all employees in the improvement of production procedures. There are two elements to improvement; the daily continuous improvement and breakthrough improvement. The continuous improvement (Kaizen) is the everyday small improvement of processes while breakthrough improvement (Kaizen Blitz) is the result of a concentrated effort on one area in production. Kaizen involves all employees in production as they are encouraged to come up with all kinds of suggestions for improvement of daily processes. Nothing is too inferior to be considered an improvement e.g. switching location of two raw materials or mounting a lamp in production as long as it increases efficiency of production. To practice Kaizen systematic collection of ideas is needed as well as routines for follow-up on the suggestions received.

Kaizen Blitz is a here-and-now process with the purpose of improving performance of one aspect of production e.g. one process, one area in the plant, or of one issue e.g. safety. It involves a team consisting of both employees and management which reviews machinery set up and production procedures to identify possibilities for increasing efficiency. During the Kaizen Blitz event changes are implemented and alterations in equipment made to immediately observe the effect of the ideas. This again may cause new ideas to emerge on how to improve the aspect of the Kaizen Blitz event and then these adjustments are made. This process continuous until the team is satisfied or the Kaizen Blitz event are over.

Kaizen Blitz events are reported to be highly efficient tools to improve production efficiency and main responsible for improvements of production performance. Between 25% and 70% improvements within a week or month are common results of Kaizen Blitz on processes not previously reviewed (Bicheno, 2004) as concentrated resources are applied. However, it is typically increasing flow and efficiency in one area of production and not in production line and needs to be repeated frequently to continuously increase efficiency.

Use of measureable parameters and exchange of information in production

Preventing waste is also about clear communication of goals to strive for in production. Lean favours measurable parameters to express the state of production, customers' satisfaction with products, number of defects, or other parameters which are found to be important for production performance. It demands systematic collection of data on performance which e.g. can be done by scheduling several short meetings (5 minutes) during production. The purpose of the meetings is to exchange information on the workload on single teams and on progress of their tasks. The information should be visually displayed on a central spot in the production area to ensure communication of state-of-production to all employees. The scheduled meetings also systematize the communication between teams and facilitate redistribution of resources to maximise the efficiency of production. This way the procedures are tools to increase efficiency in production.

2.3.4 Application of Lean in various production scenarios

As Lean origins from automotive mass production the original version of Lean principles focuses on implementation of Lean in comparable operations (Womack and Jones, 2003). However, Lean has later been applied in smaller scale production settings, in services and administration (Bicheno, 2004). These production settings differ much from mass production and a successful

implementation of Lean is often distinctly different from what is seen in Lean automotive production (Hines *et al.*, 2004). A successful application of Lean principles in different contexts implies that Lean tools are chosen in agreement with the particular setting and the types of waste and value found. The wider application of the principles has caused a natural development of Lean from shop-floor imitation of Toyota into a two level system: The operational level and the strategic level (Hines *et al.*, 2004).

Lean at the operational level refers to the shop-floor application of Lean tools and practices. This is most successful in high volume repetitive manufacturing as the Lean tools and operational practices have been developed to reduce waste in settings like these. The strategic level refers to customer-centred thinking where the principles are applied to understand and create perceived customer value. This level is applicable in all sorts of businesses including those where the operational toolkit reaches its limitations (Hines *et al.*, 2004). Hines *et al.* further suggest that the two levels of Lean as a production principle implies that application of Lean in new fields most likely will be unique to a particular industrial sector or production scenario.

Lean in the food industry

Not much literature has been published on application of Lean in production of perishable products such as food. Only two academic papers were found relevant (Lehtinen and Torkko, 2005), (Simons and Zokaei, 2006) and they both describe the effect of Lean, or tools comparable to Lean tools, at the operational level in industrial food production. Industrial production of foods can include manned lines as in the meat cutting or fish filleting industry where high output of products of homogenous quality is required within a short production window. Work is often repetitive and workers are typically on contract.

Industrial food production can also be almost completely automatic and involve only a few people in the actual making of products. Though the production scenarios differ much they both have output levels far above what

is common in institutional meal production. This means that “Lean production” appears different in the two scenarios and that the applied Lean tools will differ. It also implies that the findings of these papers cannot be directly transferred to the process of implementing Lean in meal production. Still, the papers might be used as an indicator that Lean or Lean tools can be applied in meal production as products in both scenarios are perishable and quality will change over time.

In the Lean manuscript in Chapter 3 the influence of time on food quality and the following importance of controlling time during production was one of the main arguments for applying Lean in meal production.

The application of Lean tools in red meat processing has been discussed as a tool to increase flow of production (Simons and Zokaei, 2006). The authors described observations of five meat cutting lines of which some applied production principles and tools which resembled Lean. Hence, Lean was not implemented in any of the cutting lines observed though they practiced production principles identical to some Lean principles. (Simons and Zokaei, 2006) observed that establishment of a pace in production line and standardization of procedures decreased variations in product flow. Production lines became more balanced and time spent on value-adding activities increased compared to conventional lines. It also increased homogeneity of product quality hence the authors concluded that Lean tools could be applied in red meat cutting and improve efficiency of lines and quality of products compared to conventional cutting lines (Simons and Zokaei, 2006).

The second paper found on application of Lean tools in food processing described the analysis of a production line at a contract manufacturer producing jams, marmelades, ketchup and the like. The products had long shelflives and the manufacturer used product inventories to be able to quickly respond to customer demands (Lehtinen and Torkko, 2005). The line was highly automated and variable products were produced simultaneously. Lean

tools were applied to analyse the internal processes in the company in order to minimize waste. Several value stream mapping tools were applied and the analyses uncovered whether the activities throughout the production line added value to the product. They also showed the percentage of overall resources (costs) bound to single processes and inventories in production and how the inventories could be reduced through leveled production. The authors concluded that Lean was applicable in food production as a mean to reduce costs and decrease waste (Lehtinen and Torkko, 2005).

The authors of the papers have in both cases chosen to explore and present only one aspect of Lean: Flow of production line (Simons and Zokaei, 2006) and reduction of waste (Lehtinen and Torkko, 2005). From these findings it is difficult to conclude anything on the systemwise applicability of Lean principles in food processing. However, the findings do confirm that (some) Lean tools seems to be applicable in food production; namely; pace in production and standardisation of procedures to increase flow of a manned production line with repetitive working procedures, and value stream mapping to increase flow of goods in automated productions. This is not surprising results but confirms that the application of Lean tools in production depends on the specific requirements for the given setting.

2.3.5 The use of Lean in this thesis

In this thesis Lean provides the frame for the discussion of meal production management. Further arguments for choosing Lean as a principle to manage foodservice production are included in the Lean manuscript in Chapter 3. The discussion of the applicability of Lean in meal production is based on Lean as presented in this chapter and on the findings in the Lean manuscript. The discussion is located in Chapter 4 together with the overall discussion of how Lean and Meal elements can be included in the design of foodservice concepts.

Chapter 3: Manuscripts

3.1 Meal elements manuscript

Manuscript title: Meal Elements – Convenience products for the foodservice sector

Authors: Engelund, E.H., Schultz, L., Adler-Nissen, J. and Friis, A.

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Meal Elements – Convenience products for the foodservice sector

Abstract

Purpose: To present a new concept of convenience products called “meal elements” for the foodservice sector and to describe the applicability of meal elements in a foodservice kitchen.

Methodology: A test kitchen was studied to identify needs and demands for convenience products. Pre-fried meat and vegetables were concluded to be applicable in the kitchens routines. In pilot plant, products were pre-fried using a special frying machine “the continuous wok”, frozen and distributed to the test kitchen. The quality of the products and the possibilities for applying products like these in the test kitchens menus was then evaluated by the kitchen managers.

Findings: The quality of some meal elements were readily accepted in the kitchen. The managers saw possibilities for applying pre-fried meat and pre-fried vegetables in the menus as the convenience products had an increased taste compared to traditionally prepared products and thereby would increase the taste of the meals. Portion sized pre-fried meat could be used as substitutes for traditionally fried meat and smaller sized pre-fried vegetables could also be used as filling in pies and pâtés thereby increasing the variety of vegetable products on the menu.

Research limitations: The applicability of meal elements is evaluated by the kitchen managers in a single kitchen. This implies that general conclusions on the applicability cannot be made. Further research is needed to generalize on requirements for meal elements in the foodservice sector.

Practical implication: The findings show that convenience meat and vegetable products of superior eating quality compared to traditionally prepared food components can be produced. This implies that culinary

attractive meals can be produced using less resources than in traditional cooking operations.

Classification: Research paper

Introduction

Foodservice meals are becoming an increasingly important alternative to home made meals as people tend to eat out more (Rodgers, 2005), (Shiu *et al.*, 2004), (Edwards *et al.*, 2005). Meal solutions also take a rising share of the food market in supermarkets (Ahlgren *et al.*, 2006) and in workplace canteens, schools and institutions where catering operators take over meal preparation. This increase in consumption has drawn attention to the culinary and nutritional quality of meals produced especially in captive catering (Mikkelsen *et al.*, 2007), (Hartwell *et al.*, 2006), (Wright *et al.*, 2006), (Guilland, 2003). Achieving desirable eating quality of meals produced in large scale and maintaining the quality during distribution to customers is a daily challenge to many catering operators (Hartwell *et al.*, 2006), (Rodgers, 2005). To be attractive foodservice meals must be tasty, appealing and varied from a culinary perspective (Wright *et al.*, 2006) and at the same time offer a nutritious and healthy alternative to home made meals (Guilland, 2003), (Watters *et al.*, 2003). This implies among other things that the dishes served must as a basis have a high content of vegetables to be a healthy choice and live up to the recommendations of daily intake.

To produce meals of attractive quality in large quantities within a reasonable time professional production facilities and the right equipment is needed (Rodgers, 2005). Today lack of proper equipment and facilities is a limitation for catering operators in smaller kitchens (satellite kitchens) e.g. at schools and cafeterias where kitchen facilities do not allow more than a minimum of cooking operations. However, inadequately designed equipment is also a common source to quality degradation of meals produced in larger kitchens. This may force kitchen managers to compromise on food quality since obtaining the desired product quality is too labour demanding and time

consuming – if at all possible. A solution to the problem of preparing meals with limited use of advanced cooking technology is to prepare meals from semi-prepared convenience products. However, at present the availability of adequate convenience products is limited and the quality of especially vegetable products is often unsatisfactory (Adler-Nissen, 2007).

This leads us to identify a potentially growing market for high quality convenience products from which nutritious and highly appealing meals can be produced without the use of advanced cooking technology. The convenience products must meet several quality criteria. They must first of all be of a superior eating quality compared to traditional convenience products. They must be flexible to allow high diversity in use. They must be easy to handle to minimize time used for assembling meals, and finally they must have a stable quality to limit product loss during distribution and storage.

This paper explores the acceptability of a new kind of high-quality convenience products called *meal elements* which are developed specifically for the foodservice sector. This is done by introducing concrete products in a test kitchen. By choosing this pilot test procedure it is also explored if foodservice professionals and producers have identical criteria for product acceptance. This is a general question in the process of food product development.

The meal elements included in the test are pre-fried meat and vegetables as these products can be made using an innovative frying technology “The continuous wok” described in previous papers (Adler-Nissen, 2007), (Adler-Nissen *et al.*, 2001), (Adler-Nissen, 2005) .

The general concept of meal elements is described in the following text.

The concept of meal elements

Meal elements are defined as partially prepared meal components meant for professional use. Meal elements are fresh-like ingredients, stabilized by cooling or in some cases by partial freezing for a given short period of time (days or a few weeks at the most). The meal elements can be assembled and

reheated and still yield the impression of a meal prepared of fresh ingredients. The constituents must be of the highest possible nutritional and sensory quality as meals based on elements should be superior to existing ready-made products.

Meal elements are produced centrally in large scale and distributed for easy and quick preparation of meals, allowing for greater variation and better quality. Central catering facilities can be located in the industry or at centralised production units where the adequate equipment exists. Products are subsequently distributed to foodservice kitchens for further processing or assembling to final meals.

Examples of meal elements are: pre-fried or pre-cooked meat, fish, vegetables or base sauces all which with limited further processing can be assembled to meals. By using meal elements time bound to trivial or labour intensive tasks can be transferred to the more gastronomy enhancing activities of meal preparation which are decisive for the user's impression and acceptance of the meal.

Test kitchen

The kitchen is located at Rygårds Centret in Gentofte municipality in the greater Copenhagen area. Rygårds Centret is a nursing home and a daytime centre where elderly people can buy meals and participate in different activities. They produce 325 hot meals on a daily basis some of which are distributed to three other nursing homes in the municipality. Hot meals are available for lunch and open sandwiches are served in the evening. The meals at Rygårds Centret are served in a restaurant-style room with the nursing staff as "waiters" and the users seated together at small tables. Hot meals are produced during the morning and are kept warm at 80°C until the time of serving. The different parts of the meals are prepared in prioritized order to minimize quality degradation during the warm-holding period with soups and sauces prepared first and vegetables prepared as close to the time of serving as possible. However, sometimes the meals are kept warm for 1-2 hours before consumption.

Today the kitchen uses convenience products in the form of bake-off bread, bouillons for sauces and soups, and pre-cut, raw vegetables. Also frozen or canned vegetables and powdered products are in use.

The meals served are mainly traditional Danish dishes with casseroles, roasts, and fried or baked meat and fish. The procedure for preparing meat or fish in serving size portions includes surface browning at a large frying table followed by baking. The two-step procedure is necessary to produce a brown surface and a well-done product. As many pieces are fried simultaneously it is difficult to control frying time of the single pieces of products and the result is uneven product quality.

A majority of the vegetables is steamed before serving or boiled in casseroles. Meat, bacon and vegetables in casseroles are boiled without initial browning as the frying would take up too much time in production. The result is that ingredients are less tasty and paler than if they had been fried before boiling. As casseroles and stews are common servings in the kitchen the managers would like to add browning to the preparation procedures and thereby improve the eating quality of this type of dishes.

Vegetables are seen as an important part of a nutritious diet and the kitchen managers seek to add more vegetable products to the menus. These should be based on heat treated vegetables as the elderly have a preference for these products and they are easy to chew. Vegetable pies, pâtés and quiches are preferred to simple vegetable products as the calorie content may be high in these complex products. The energy content is important for the kitchen managers as supplying the elderly with sufficient calories is a serious problem. However, the kitchen has limited time available and time consuming tasks to perform like preparation of raw vegetables followed by frying and mixing with other ingredients are difficult to add to the daily cooking routines. Thus using convenience products in the production is a way to increase the vegetable content of the meals served without increasing the time needed for cooking processes.

Methodology

Decision on which meal elements to prepare

The test kitchen was visited during three days and production procedures were observed. The visits were planned together with the kitchen managers as the meals on the menu these days had to be representative in a broad perspective. The observations included identification of cooking operations which could be substituted by pre-fried meat or vegetables. Menu plans were studied as well to identify meat and vegetable components of other dishes which could be substituted by pre-fried meal elements. For the later discussion on the applicability of meal elements it was decided also to prepare a variety of vegetable products not found in existing menus and to include these in the test.

Preparation of pre-fried meal elements

Raw products were bought at a local supermarket and immediately transported to the pilot plant where the production took place. Vegetables were peeled, if necessary, and cut into adequate pieces. Meat was cut into dices or slices depending on desired product characteristics. Raw ingredients were added 1 % w/w of Debic “Roast and fry” (frying oil with clarified butter and vegetable oil) except for mushrooms and turkey which was added 2 %. The frying process most resemble the stir-frying process known from Asian cuisines as it involves high rates of heat and high mass transfer and simultaneous continuous stirring of products. The process and product characteristics are described in detail in previous papers (Adler-Nissen, 2002), (Adler-Nissen *et al.*, 2001), (Adler-Nissen, 2005), (Adler-Nissen, 2007). The products prepared, details of the frying procedures, and resulting product qualities are presented in Table 1.

Table 1. Preparation and pre-frying of selected meal elements

Product	Cutting	Frying parameters	Fried product characteristics
Carrot	Sticks: 4*0,5cm	6 min, 240°C	Ready-to-serve
Pepper, red, green, yellow	Dices: 0,5-1 cm	5 min, 250°C	Ready-to-serve
Red onion	Slices: 0,25-0,5 cm	2 min, 245 °C	Ready-to-serve
Red beet	Dices: 0,5-1 cm	7 min, 270°C	Ready-to-serve
Mushroom	Quarters	5 min, 270°C	Ready-to-serve
Turkey fillet	Dices: 2-3 cm, 10 g	6 min, 285°C	Ready-to-serve
Pork tenderloin	Slices: 2 cm	4 min, 285°C	Rare (red) center Needs further heat treatment
Pork liver	Slices: 2 cm	7 min, 285°C	Rare center Needs further heat treatment
Bacon	Dices: 0,5-1 cm	6 min, 240°C	Ready-to-serve

The frying parameters were adjusted during the experiment to obtain the desired quality of products. Fried carrots and peppers should have a firm texture, a partly browned crust and a roasted flavour while red onions should be crispy and retain a mild but characteristic onion flavour. Red beets should have a softened texture and a roasted flavour while mushrooms should be browned and juicy with a firm texture and a roasted flavour. Turkey fillet, pork tenderloin and pork liver should be browned and have flavours of roasted meat and juicy textures. Slices of pork tenderloin and liver should have a rare centre after frying and bacon should have a distinct fried flavour, a crispy texture and a dark colour.

All products should be prepared as ready-to-serve products except from tenderloin and liver which should remain rare in the centre to minimize the risk of a dry product after re-heating.

Following frying of each batch of products were blast frozen at -40°C, placed in plastic bags and stored at -20°C for two days.

Evaluation of meal element quality and identification of applications

The fried products were removed from the freezer and frozen carrots, peppers, mushrooms, turkey, tenderloin, liver, and bacon put in a polystyrene box and transported 15 minutes to the kitchen. Red beets and red onions were placed outside the polystyrene box and these were thawed during transportation. When arriving to the kitchen the products in the polystyrene box were still frozen. Frozen products (carrots, peppers, mushrooms, turkey, tenderloin, liver, and bacon) were spread out in a single layer at separate plates and reheated by the kitchen managers using a convection oven at 170°C (for approximately 20 minutes varying with products). This procedure was chosen as it resembled the heating and baking process already applied in the kitchen. Reheated products were placed on white plates. The kitchen managers were then asked to taste the products and to evaluate the eating quality by considering appearance, taste, juiciness, and texture of products. These characteristics were suggested to be most important for kitchen managers' evaluation of meal element quality as texture (juiciness and tenderness), flavour and appearance are generally accepted as most important factors for consumer's food acceptability (Kilcast and Fillion, 2001) (Aaslyng *et al.*, 2003) also among foodservice personnel (Guilland, 2003). They were also asked to comment on applicability of the pre-fried products and to express demands for specific qualities and characteristics. The results of the evaluation are shown in Table 2 and Table 3.

Results and discussion

Kitchen managers' evaluation of meal element eating quality

Results from the managers' evaluation of the eating quality of meal elements are presented in Table 2 together with comments on the overall product quality.

Tabel 2: Kitchen managers' evaluation of the quality of pre-fried meal elements

Product	Quality evaluation after reheating ^{1,2}	Comments on product quality
Carrot	Fried taste and appearance, firm texture.	Too firm to serve without additional heat treatment Not ready-to-serve
Pepper: red, green, yellow	Fried flavour, emphasized sweetness, crispy texture	Good Ready-to-serve
Red onion ¹	Fried onion flavour, sweetened taste, crispy texture	Good Ready-to-serve
Red beet ¹	Fried flavour, firm texture	Very good Ready-to-serve
Mushroom	Fried flavour and golden-brown appearance, softened texture	Very good
Turkey fillet, dices ²	Fried meat flavour. Brown colour. Before reheating: increased juicy texture compared to existing products After reheating: dry and hard to chew	Turkey becomes dry after reheating. Dices are too big Ready-to-serve as cold product
Pork tenderloin, surface browned and red core	Meat flavour, juicy and more tender than existing products	Very good but meat slices are too small to fit into the menus
Pork liver, surface browned and red core	Pork liver taste, brown surface	Pork liver is not on the menu, calf liver is
Bacon	"Fried bacon" appearance and flavour.	The colour is too light Ready-to-serve

Notes: ¹ Red onion and red beet were not reheated before evaluation

² Turkey fillets were evaluated both before and after reheating

In general, meal elements were evaluated by the managers as having a distinct fried taste and appearance. Tenderloin and turkey had a "fried" flavour, a brown crust and juicy texture before reheating and turkey had a distinct fried taste. Tenderloin remained tender after reheating so did the pork liver but turkey was evaluated as dry and the dices were too big. Bacon had a good flavour and looked "fried" but was light coloured. Vegetables in general had a fried flavour and taste and a crispy or firm texture. Carrots were too firm to be served without additional heat treatment but peppers and mushrooms were evaluated as being tasty products ready-to-serve directly after reheating. The red beets and red onions were evaluated together as cold components of a salad. The beets had a mildly fried taste and a firm texture while onions had a sweetened taste and a crispy texture. Both products were classified as

ready-to-serve without re-heating and especially the red beets were evaluated as being a very good product.

Kitchen managers' comments on applicability of meal elements in the menus

The kitchen managers' evaluation of how meal elements could be applied in the existing menus is presented in Table 3. Their immediate ideas for how the pre-fried products could increase variety of servings in the kitchen are also included in the table.

Table 3: Applicability of meal elements and increased variability of dishes

Product	Application	Increases variability in menus
Carrot	A substitute for steamed carrots used in casseroles. Salad buffet Side dish variation Filling in pâtés	Yes, as topping in salads, side dish, and filling
Pepper: red, green, yellow	In casseroles, salad buffets Filling in pies or pâtés	Yes, as topping in salads and filling Side dish when mixed with other vegetables
Red onion ¹	Ingredient in salads, Casseroles	Yes, as ingredient in new salads
Red beet ¹	In salad with dressing and herbs. Side dish variation Filling in pâtés	Yes, as topping in salad buffet or ingredient in new salads and as filling in patés
Mushroom	Salad buffets, casseroles and sauces. Filling in pies or terrines In soups Substitute for canned mushrooms	Yes, as topping in salads and filling
Turkey fillet, dices	In casseroles or cold servings, salad topping	Yes, as cold servings and topping in salads
Pork tenderloin, surface browned and red core	Meat serving. Substitution for present surface browning process	Yes, if served with a variety of sauces
Pork liver, surface browned and red core	Meat serving. Substitution for present surface browning process of liver	Yes, if served with a variety of sauces
Bacon	Casseroles, toppings, pies	Yes, as topping in salads and in pies

The kitchen managers evaluated most of the fried meal elements as being different to existing fried products presently available in their meals. Only pork tenderloin was seen as a product which could be directly compared to traditionally prepared products.

Fried turkey meat had a browned colour compared to the boiled pale turkey meat which made it suitable as topping in salads as well as a component in casseroles. Pre-fried tenderloin remained juicy and tender after reheating and the managers evaluated this product as easy to apply in several existing dishes. They immediately came up with ideas for dishes in which pre-fried tenderloin could substitute conventionally prepared tenderloin. They also saw possibilities for creating several dishes from the tenderloin and varying combinations of sauces, spices and side dishes.

The pre-fried liver was of little interest to the managers as it was pork liver and they used only calf liver; this is trivial to change, however.

The fried vegetables were seen as new products with quality much different from existing products. Taste, appearance and texture made the products fundamentally different and difficult to compare with existing products. The pre-fried vegetables were generally evaluated as good substitutes for existing products especially in casseroles as the frying enhanced the taste of the dishes. Fried vegetables could also be used in pies and pâtés or be mixed and served as side dishes and can in that way increase the variety of menus. The managers compared fried carrots to frozen convenience carrots as these products were to be used much in the same way. The texture of pre-fried carrots was much firmer than that of conventional frozen carrots and it was decided that the pre-frying needed to be adjusted to fit the demands of easy-to-chew products which was needed in the test kitchen.

Product acceptance criteria

The quality criteria initially defined as most important for product acceptability were; Eating quality, flexibility to mix products, easiness of handling products, and stability of product quality. These characteristics were all seen as important aspects of the overall quality of convenience products. Most energy

was put in achieving the desired eating quality of meal elements and on how the initial production step should be coordinated with the following reheating procedure to obtain the best possible eating quality of end products.

Kitchen managers were asked to evaluate the eating quality of products (appearance, taste, texture) and the applicability of products in menus. While they did so they evaluated quality parameters which were not given much consideration during production of the meal elements. These were: “size” of dices and slices of meat, “type” of meat and the “end-users demand” of an easy to chew product. These parameters appeared to be quite important to the kitchen managers as the overall quality (eating quality and applicability) was perceived to be lower when the pre-fried meal elements failed to live up to these internal quality criteria. At the same time the handiness of products or the possibility for minimizing product loss when using frozen products were not commented at all. This indicates that the kitchen managers at the initial acceptance stage were indifferent to these convenience attributes and that eating quality and physical appearance of products were more important for acceptance. The convenience of products though may be considered relevant at later stage in the acceptance process.

In the pilot test the researchers believed that explaining the theoretical benefits of using meal elements in foodservice (increased flexibility of meal preparation, little product waste, less time used to assemble meals) would lead to an overall positive evaluation of the concept. They regarded characteristics like size of meat pieces and type of raw material as having little influence on the perceived quality of the meal elements as they saw these characteristics as adjustable. Hence, they expected a neutral evaluation of the concept of meal elements but failed to achieve this as the kitchen managers perceived the specific characteristics of the test products (appearance and type of raw ingredients) as an integrated part of the concept of meal elements. Thus the kitchen managers included these attributes in their evaluation of product quality as these aspects were crucial in the daily meal preparation.

The test shows that there are differences between the producers' (the researchers) and the users' (kitchen managers) perception of product quality attributes and in their ranking of the importance of these attributes. It also shows the importance of carefully defining the parameters to be evaluated when testing new products.

The differences in quality perception can be explained by the quality evaluation process suggested by (Sloof *et al.*, 1996). These authors suggest that product acceptability is a combination of characteristics of the product itself, criteria imposed by the user of this product and possible substitute products. This explanation implies that product quality cannot be evaluated without considering the specific use of the product: when a new product *in theory* may fulfil users' requirements this is not automatically the same *in practice*.

The concept of meal elements prescribes that products are prepared to be used in a specific production and distribution scenario. Considering the experiences from this study this approach should also be taken in pilot studies of the applicability of products in test kitchens.

Conclusion

There is a need for development of high quality convenience products for the foodservice sector. These products must live up to the requirements for product characteristics set by foodservice professionals. This means that taste, texture, flavour and appearance of products must be appealing to the professionals but just as important is the ability of products to live up to quality criteria specified by the procedures and routines in the individual kitchen.

Meal elements proved to fulfil many of the identified requirements for convenience products. When evaluated by foodservice professionals pre-fried meat meal elements showed use as fried meat components in the existing meals and pre-fried vegetables could be used as components in casseroles, as side dishes or as ingredients in salads. The findings show that it is possible

to prepare convenience products which are found tasty and attractive by foodservice professionals.

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3.2 Lean manuscript

Title: Optimization of large scale food production using Lean Manufacturing principles

Authors: Engelund, E.H., Breum, G. and Friis, A.

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Optimization of large scale meal production using Lean Manufacturing principles

Abstract

This paper discusses how Lean Manufacturing principles (Lean) can be applied in large scale meal production. The Lean concept is briefly presented followed by a field study of how the kitchen at a Danish hospital has implemented Lean in the daily production. In the kitchen Lean was chosen as a way to optimize internal procedures (with respect to production efficiency, product quality and working environment) in the process of changing from cook-serve production to cook-chill and at the same time reducing staff. The field study shows that Lean can be used to increase production efficiency and improve product quality in the kitchen as well as maintain focus on good working environment. The results also show that Lean is useful in managing meal production procedures and it is concluded that Lean in general can help optimising and managing procedures in large scale meal production.

Introduction

Public foodservice in many countries is undergoing changes these years this includes Denmark (Mibey and Williams, 2002); (Silverman *et al.*, 2000); (Hwang *et al.*, 1999); (Engelund *et al.*, 2007). Traditionally foodservice has been organized with the production carried out in kitchens placed near the users of the services. To reduce production costs sites have been concentrated in fewer, larger kitchens from where food is distributed to satellite kitchens for final preparation and serving (Engelund *et al.*, 2007). This restructuring has often been combined with a change in the applied production methods and production technologies to enable increased output quantities. Cook-chill is the prevalent production principle which is often combined with use of modified atmosphere packing (MAP), hot fill and similar packing methods which all aim at prolonging the shelf-life of the meals (Benner *et al.*, 2003); (McClelland and Williams, 2003). Cook-chill systems are

more efficient than traditional cook-serve production and generally bring the possibility of reducing staff and thereby cost of production (Clark, 1997); (McClelland and Williams, 2003).

The replacement of traditional cooking procedures with cook-chill technology and concurrent separation of cooking and serving introduces a new paradigm in large scale meal production. When technology changes and output reaches a certain size the traditional cooking procedures established for smaller scale cook-serve production are no longer suitable. They do not automatically fit production systems with increased scale of output since criteria like volume to surface ratio and product time temperature history are altered (Rodgers, 2005b). Internal production processes must change to reflect demands for increased output especially when the number of employees is simultaneously reduced. Hence, rethinking of procedures and management of operations become increasingly necessary to maintain control of product quality when changing production system (Rodgers, 2005a).

In this respect the applicability of Lean Manufacturing principles in the management and production of meals in large scale is discussed and a field study of the practical implementation in a large kitchen is presented.

In short Lean is a Japanese production management concept aiming at eliminating all sorts of waste from production. Eradicating waste and thus increasing efficiency throughout the production chain lead to reduced production costs as well as increased value (of product) in the eyes of the customer (Hines *et al.*, 2004). Meal quality is closely related to the process parameters time and temperature which must be controlled carefully. Lean offers increasing focus on internal control of processes which besides reducing costs of production also helps improving quality of products. Some applications of Lean in the food industry are described and discussed previously (Stevenson and Jain, 2005); (Simons and Zokaei, 2006); (Lehtinen and Torkko, 2005); (Taylor, 2006); (Cox and Chicksand, 2005) however, this does not include applicability of Lean in production of meals for catering purposes.

This paper starts with an introduction to Lean, followed by a presentation of the field study and a description of the implementation of Lean in this kitchen.

Methodology

This research is a field study-based discussion of how large scale meal production can benefit from applying Lean in daily management and production planning. The case kitchen at Glostrup Hospital was visited twice during the implementation process and the managers were interviewed about procedures and perspectives of working with Lean in the kitchen. Based on the interviews the application of Lean in the kitchen was described. The discussion focus on the results gained so far, and which principles have proved most applicable in obtaining the goals set by management.

Lean is discussed at plant level (door to door level) in contrast to supply chain level, multiple plants level and single-process level (Rother and Shook, 1999). The same approach is used in the discussion of lean in red meat processing (Simons and Zokaei, 2006) and in production of ketchup, jams and the like (Lehtinen and Torkko, 2005) and is generally accepted (Rother and Shook, 1999). As the discussion is limited to production plant level internal procedures are discussed and supply and distribution only briefly considered.

Lean Manufacturing principles

Lean Manufacturing originally stems from the Japanese car producer Toyota. It is described by Womack and Jones (Womack and Jones, 2003) and Bicheno (Bicheno, 2004) to name some of the most prominent western authors. The authors found Toyota's car production (based on the Toyota Production System, TPS) highly competitive and superior to western production systems (mainly those applying batch and queue principles) and made it their mission to spread the knowledge of this production principle. To reflect the fitness of the system they gave it the name "Lean". Car production

can be characterized as high volume repetitive manufacturing (Hines *et al.*, 2004) or mass production (James-Moore and Gibbons, 1997) and the original version of Lean focuses on explaining the benefits in similar operations.

However, during the years Lean has been adapted to fit a variety of industries, administration and services with great success (Bicheno, 2004); (Bowen and Youngdahl, 1998) which all have production operations differing from mass production.

Womack and Jones claim that Lean is a tool to “banish waste and create wealth in your corporation” (Womack and Jones, 2003). Other characterize Lean as: “an intellectual approach consisting of a system of measures and methods which when brought all together have the potential to bring about a “lean” and therefore particularly competitive state in a company” (Warnecke and Hüser, 1995). Yet others says that Lean is “giving people at all levels of an organisation the skills and shared means of thinking to systematically drive out waste by designing better ways of working, improving connections and easing flows within supply chains” (Wood, 2004). No matter the definition the message is that continuous focus on value-adding activities through elimination of waste and assurance of flow in a process will increase competitiveness of a company and cut down costs of production.

Production philosophy and tools

According to Womack and Jones a Lean process can be achieved by incorporating a set of specific principles in existing operations. The integration demands use of certain tools and techniques which the authors describe (Womack and Jones, 2003). These are briefly explained below and some are later on discussed in further detail.

The critical starting point is determination of product value as it is perceived by the end customer. This is important as every activity throughout the production should add customer perceived value to the product. The second principle is to identify value adding activities in the production line. To accomplish this overview of procedures is paramount, and this can be obtained by using the Lean tool “value stream mapping”. Value stream

mapping refers to the identification of every step in a process from product design, development, manufacturing, distribution, etc. including location of production equipment. From the map, both value adding and non-value adding activities (e.g. detours, waiting, and excess processing) are visualized. Value stream mapping clarifies process chains for single products and elucidates non-optimal procedures in process lines. The third principle is to let the value-creating activities be connected in line. Processes must be planned so that bottlenecks or “batch and queue” processes are avoided and continuous flow through production obtained. This demands coordination of all procedures and requires the production to follow a certain pace. The fourth principle deals with production scheduling and is based on letting the customer pull products from the production. This means that nothing is produced upstream unless it is needed downstream. This principle is in contrast to batch and queue procedures, as seen in mass production, and pull production aims at reducing the resources locked up in inventories. This implies that production must be just-in-time both internal between processes and externally when delivering products to the customer. The fifth and final principle pertains to continuously pursuing perfection in processes. It involves all employees at all levels in a company and requires systematic visualization of the progress obtained. It is not only about creating the product that the customer requires with a minimum of defects but includes the perfection of every action in connection with the production process.

Absence of procedures categorized as waste is needed to obtain value throughout the production chain as wasteful activities add no value to the customer but incur extra production costs. In Lean, waste is defined as any human activity that absorbs resources but creates no value (Wood, 2004). Waste is waiting, excess transporting, overproduction, production of defects (rework products, paperwork errors and mistakes), unnecessary motion (moving of people), inventories (overstocking), and unnecessary processing (packaging, wrong equipment for job). Design of goods and services which do not meet customer's needs and untapped human potential has also been added to the list of waste.

Avoiding wasteful activities demands a housekeeping discipline throughout production area and in office. In Lean the system “5S” is applied. The 5S stands for: Sort (equipment, remove what is not used), Simplify (equipments and tools must be in the right place), Sweep (tidiness but also routine checking of equipment for defects), Standardise (working procedures), and Sustain (the housekeeping is an ongoing procedure).

In summary, Lean is about delivering best possible product value to the customer while optimizing use of resources in production. The method is elimination of waste through use of the Lean tools. The involvement of everyone in the continuous process of driving out waste of procedures is what makes Lean a philosophy rather than merely a production principle. Once started improving working processes is a never-ending procedure which must be integrated in job routines (Bicheno, 2004); (Womack and Jones, 2003).

Lean and meal production

The central hypothesis of this paper is that Lean principles can improve large scale meal production. The questions to be answered are how this may look in reality and why the principles are useful?

Lean stems from mass production of non-perishable goods thus all Lean principles and tools may not be equally applicable in production of perishable products like foods. It is important to consider the specific characteristics of meal production before planning the management of large scale meal production operations.

The most important characteristics of meal products include the perishable nature of raw and processed material (Stevenson and Jain, 2005) and the irreversible change in product quality during processing and over storage time (Benner *et al.*, 2003); (Mibey and Williams, 2002). The quality of meals produced is complex to define and usually parameters like odour, colours, microbial population, and vitamin retention are used as indicators (Rodgers, 2005b). These parameters are difficult to measure in a large scale kitchen

thus it is extremely important to control production parameters during processing as well as in storage of intermediate produce and the final product. It should also be recognised that non-optimal processing may not have an immediate effect on product quality but can show later when e.g. the storing ability is reduced or product sensory quality is hampered. Therefore a production principle suitable for meal production must focus on controlling process parameters as these are determining output quality.

In Lean, analysis of a production line is performed to uncover wasteful procedures which incur cost of production. In meal production, however, non-optimal procedures not only increase cost of production but may also reduce product quality. Hence, the Lean principle of optimising product flow through value-adding processes is in perfect agreement with traditional characteristics of meal production.

Less relevant to large meal production are some of the tools offered to obtain a highly standardized production running at a certain pace. Standardized procedures are extremely useful in food production and determining pace of production (time used for preparation of single components) is advantageous in all kinds of mass production including food (Simons and Zokaei, 2006). Cooking of meals seldom has the volume of true mass production and procedures can only be standardized to the point where natural variation in raw material must be considered. Therefore, "Lean meal production" does not require application of all Lean principles and tools in their original form and some adaptation to the specific characteristics of meal production is necessary.

The case kitchen

Glostrup Hospital is situated in the greater Copenhagen area in Denmark. The central kitchen is situated inside the Hospital grounds in a separate building and every day meals for about 1000 patients are distributed from the kitchen.

In 2005 the Hospital's management took a general decision that all services should be "Lean". To cut costs of meal production the kitchen was forced to replace cook-serve production with cook-chill and cut staff by some 16 employees which is equivalent to about half of the original work force. This brought about a need for reviewing and optimising production procedures to keep up the output quantity with fewer employees. The change of production system to cook-chill also inflicted on the end-product quality as recipes and production procedures needed adjustments. Therefore, systematic evaluation and improvement of product quality was highly prioritized in the kitchen. The manager of the kitchen focused much on the internal working environment and insisted on maintaining this as a high priority during the rationalization. It was important to the manager that increased efficiency of production processes was obtained by optimization of procedures and not by making staff run faster.

Due to these reservations the implementation of Lean should result in both increased efficiency of processes and improved product quality while ensuring a pleasant working environment for the remaining employees. The implementation of Lean in the kitchen began shortly after the change to cook-chill processing and in due time before procedures became routine.

Production of meals in Glostrup Hospital's central kitchen

The kitchen produces most components of the meals themselves including bread, soups and processed vegetables. Only when time is scarce or production fail, frozen convenience products are used. Previously with the cook-serve production there were separate lines for production of: hot meal components, vegetables, baked products, desserts and cold products (traditional Danish "smørrebrød" or open sandwiches, sandwiches, breakfast etc.). For these meals all items were prepared, processed and kept warm until serving. Initially when changing to cook-chill production separation of production according to meal was maintained. Processed meal components

were assembled to final meals, packed and stored up to 3 days before final distribution to the hospital wards. The packing is standardized in 2, 5 or 7 portions per package and wards received the amount of portions which was closest to their actual order. This practice of standardizing packaging was accepted by the management as a dogmatic practice of cook-chill production. The kitchen staff was highly international as employees count 12 different nationalities. This complicates conversation and the manager has chosen to overcome this problem by using both visual effects and written words in the daily communication.

Application of Lean in the kitchen

The kitchen had 3 focus areas during the change to Lean, namely improvement of efficiency to reduce costs, improvement of product quality, and maintaining a pleasant working environment in the kitchen. In the following the concrete application of Lean is described. A general tool used throughout the change process is the definition of measureable parameters to visualise progress of single projects.

Improving efficiency of production processes in the kitchen

The challenge in becoming Lean is to increase production efficiency and increase flow through processes and at the same time reduce waste. Selected Lean tools were applied in production to discover how existing procedures could be optimized namely, value stream mapping, visualization of product waste, Blitz Kaizen (an eye-opener tool in which a concentrated effort in a selected area in production leads to fundamental improvements of productivity (Bicheno 2004)), and the housekeeping discipline 5S.

Value stream mapping of a single product was the first tool used to visualize existing flow in processes. The experience from this was subsequently used to uncover flow in other processes. Special focus was brought to the procedure of packing and storing meals up to 3 days before use. Meals were prepared, portioned in standard sizes and packed before actual orders were

received and this often hindered distribution of the exact number of meals ordered. This routine was in direct contrast to the just-in-time principle in Lean and was a non-value adding procedure since it prolonged the time products stay in kitchen facilities to an unnecessary extend.

Product waste was visualized as the number of excess meals distributed due to packing in fixed sizes. This procedure contradicts the “pull” principle in Lean which dictates that products should only be processed when orders are received to minimize waste.

Blitz Kaizen activities were performed in selected areas of the production. The “cold production” was first to have its routines observed, discussed and optimized as procedures were found to include much excess handling of products. Next in line was the packing facilities and transport equipment. The Blitz event should give an immediate boost to productivity in the area by changing equipment set up and routines to increase flow in processes. The housekeeping system, 5S, was applied in separate parts of the production facilities to increase tidiness and standardize placement of equipment and raw materials.

Evaluation and improvement of product quality

The implementation of cook-chill procedures in production called for a systematic evaluation of product quality. A graph on display in production facility showing the daily number of complaints was chosen as an expression of daily customer satisfaction with product quality. The number of complaints for each meal component was summed up based on feedback received from wards and patients and was each day marked on the graph. This procedure was chosen as a way to unify communication of customer product satisfaction to all employees.

An internal quality control system has been developed to reflect the need for adjusting recipes. It consists of a three colour graduation of product acceptability where red refers to “not acceptable”, yellow is “acceptable” and

green is “good”. Testing of product quality is performed internal in the kitchen and products must obtain a yellow mark to pass. This system has been developed to visualise the progress of adjusting existing procedures to cook-chill production and is based on the Lean principle of using measureable parameters to express status of focus areas.

The quality systems use visual parameters to facilitate communication with staff of all nationalities.

Maintaining focus on working environment

The working environment was addressed through teamwork and joint responsibility even before Lean was implemented in the kitchen. This was extended to involve continuous improvement of processes. Process improvement was based on facilitation of job routines as the way to optimize production flow. To involve staff as much as possible in continuous improvement of processes systematic collection of suggestions for improvement was needed. A system to do so was established (a white-board with a drawing of production facilities, post-it stickers and a pen to write down suggestions located in the production area). Meetings were held 3 times a day at this board where teams reported production status to the management. This procedure ensured that staff had regular contact with the white-board and that it was easy to come up with improvement suggestions by placing a sticker. It also facilitated relocation of ressources between teams when work load demanded so.

All employees participated in weekly meetings to follow-up on existing projects and prioritize new suggestions for improvements in agreement with the Lean principle of involving employees in process improvement.

The performance of the working environment was expressed through employee absence due to illness and scale of overtime. The change to cook-chill technology had increased overtime in the kitchen and staff urged to

normalize this. Therefore these parameters were chosen to express the temperature of the daily working environment.

Results

Improving efficiency of production processes

The four tools: value stream mapping, visualization of product waste, “Blitz Kaizen” and implementation of 5S were all contributing to improved efficiency in production but had different roles in the process. Hence it was difficult to make a fair split up of results according to each tool. Value stream mapping made clear that the storing procedure of finished meals was a wasteful activity and contradicted the principle of letting customers pull products from production. Waste from distribution of excess meals was measured to 10% of the number of meals distributed. The portioning procedure was following changed and only low cost products (porridge, sauces, soups) were portioned in standard sizes while meat were portioned and packed when orders were received. This reduced the number of meals wasted to 5%. A further reduction demands feedback of waste at ward level but this cannot be established at the moment due to internal barriers.

The direct effects of Blitz Kaizen events and implementation of 5S were difficult to measure as these tools support the process of increasing flow in production. Blitz Kaizen caused changes in the processes and relocation of equipment in the three areas; cold production, packing room, and transport equipment which have benefitted the flow in production. Defects were fixed and equipment optimized to facilitate production routines. Still, some non-value adding handling had to remain due to temperature requirements (quality related) of cooling products. The implementation of 5S in storing facilities resulted in improved organization of wares and raw materials which decreases time used for locating ingredients.

Another initiative designed to increase efficiency was to change production planning from *meals* to *processes*. Production of similar components of different meals was changed to be one consecutive procedure in contrast to the former finishing of one meal at a time. The new practice reduced change-over times in processing and is primarily advantageous in cook-chill production. This is because distribution must be timely separated from processing of meals to show an effect of gathering production of similar products.

Evaluation and improvement of product quality

The use of measurable parameters (number of customer complaints and the colour system for recipe acceptability) provided the staff with benchmarks for product quality. The systematic evaluation of product qualities clarified where improvements were needed and a focused effort involving all relevant staff could be established. Combined with the use of cook-chill technology this has made the kitchen less liable to accept meal products of reduced quality as it is now general acceptable to re-do products in order to improve product quality.

Maintaining focus on working environment

The involvement of staff in continuous improvement of working processes and establishment of ways to collect suggestions has caused the number of ideas for changes to increase. The actual numbers of suggestions before and after implementation of Lean have not been collected but the managers' clear impression was that the number has risen. The suggestions cover everything from relocation of process equipment and raw material in storing facilities to suggestions for changes in production procedures.

The weekly follow-up meetings have made more people interested in taking part in the process of improving working processes. Before introduction of Lean a limited number of staff commented on production procedures and

improvement of processes were seen as management's responsibility. However, as the new process with weekly meetings became more established and employees were confirmed that their suggestions for improvements came into action an increasing part of staff has taken interest in this process.

Team spirit across existing teams has been improved by establishment of the 3 daily status meetings. As information of work load and time pressure was shared among teams they increasingly help each finishing production tasks.

The focus on reduction of overtime caused a more flexible approach to the planning and performing of production. As reduction in staff number due to illnesses, vacations, and holidays was a returning event a general procedure to minimize production tasks during these periods was established. This involved a change in menu production so that less work intensive meals were substituting more demanding menus during these periods. In this way overtime was reduced.

Another outcome of the focus on working environment and reduction of overtime was the establishment of more flexible job tasks. An employee with e.g. an aching back was offered part-time job or a change in job tasks to reduce the amount of absence due to illness and minimize loss of resources. This caused a change in attitude among staff to the matter of when you are too ill to go to work and was part of the solution on the problem of reducing overtime in the kitchen.

Discussion

The field study shows how Lean principles and tools can be successfully applied in meal production in a hospital kitchen. The implementation of Lean is a continuous change process and thus it is difficult to quantify all results. Instead progress can be expressed by qualitative evaluation of the effect of principles implemented, actions taken, and changes made to the organization

to achieve improved performance (Karlsson and Åhlström, 1996). Following this procedure the results are:

1. Increased flow as a result of optimizing handling routines in selected areas and planning of daily production
2. Reduced product waste from changed storing and portioning routines
3. Improved efficiency of storing, transporting and packing procedures
4. A common system involving all employees in improving/evaluating product quality
5. Increased team spirit
6. Reduction of overtime

The 6 results show that implementing Lean principles and tools have caused positive changes to the focus areas “efficiency” (1-3), “product quality” (4), and “working environment” (5-6). Hence, the Lean tools have proven to be applicable in meal production though the success has been varying. Value stream mapping, use of measurement and visual presentation of key parameters, 5S, Blitz Kaizen, and increased involvement of staff in improvement of processes have brought visible results to the kitchen. The efforts to increase efficiency did not result in achievement of Just-In-Time production and consistently pull production as this require a dedicated cook-serve production. Still, the principles challenged the managers to change portioning procedures towards just-in-time and portioning of more expensive meal components now reflects actual orders.

In meal production routines are forced to consider the special characteristics of food and respect official temperature requirements. This may cause handling of products which are categorized as waste in production of non-perishable goods. An example of this was seen in the “Cold kitchen” area where optimized procedures still contain non-value adding handlings to ensure adequate cooling of products. As well the meal distribution system at the hospital limited the successful reduction of waste due to internal organisational barriers. Thus, successful application of Lean in meal production depend not only on the internal production planning and

performance but is influenced by choice of system, official requirements and work organization in surrounding systems.

Conclusion

Traditional large scale meal production has problems with obtaining desired qualities of meals served and maintaining the costs sufficiently low. The use of cook-chill systems has made large scale cooking of meals comparable to larger scale industrial production and this has brought about a need for reviewing planning procedures and management of operations. Lean Manufacturing theoretically fit the special characteristics of meal production as improved product quality through optimized production planning and strict control with process parameters are main objectives.

The field study of Lean in a hospital's central kitchen shows that the Lean tools: Value stream mapping, measuring and visual presenting key parameters, 5S, Blitz Kaizen, and increased involvement of staff in improvement of processes have led to increased efficiency in the kitchen. Implementation of Lean has also resulted in measurement of product quality and of visual presentation of daily customer satisfaction. From continuous collection of customer feedback systematic efforts to improve product quality was established. In the kitchen Lean tools have also shown useful to increase employee involvement in improvement of production and in increasing team spirit across teams. The field study shows that Lean Manufacturing principles can improve efficiency of meal production but that the resulting effect is dependent on production system and external conditions. However, in general the application of Lean can improve performance of meal production systems.

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Chapter 4: Results and discussions

4. Results and discussions

This chapter summarizes the findings of the Meal elements manuscript and the Lean manuscript. The results presented in the manuscripts are discussed in relation to the two hypotheses of the thesis as the manuscripts represent the research done to test the hypotheses.

Then, conclusions are discussed in relation to the two frameworks applied on institutional foodservice: 1) The concept of Meal elements and 2) application of Lean in production.

Finally, the findings are discussed in relation to the overall aim of this thesis: to contribute to the work of improving the quality of meals prepared in institutional foodservice systems.

4.1 Findings from the Meal elements manuscript

The purpose of the manuscript was to present the concept of meal elements to foodservice professionals and to have their evaluation of quality and applicability of the convenience products. This was done by introducing a variety of pre-fried meat and vegetable products in a test kitchen and asking kitchen managers to evaluate the sensory qualities of these products as well as the possible use of the products in the kitchen.

The findings showed that most of the pre-fried meat and vegetable products had an acceptable sensory quality. The findings also showed that the quality of pre-fried vegetables were different from existing convenience products and of the traditionally prepared vegetable products prepared in the kitchen. Hence, meal elements supplied a new kind of products to the kitchen.

The products were evaluated as applicable in the kitchen if initial frying and cutting were adjusted to actual conditions and requirements in the test kitchen. Application of meal elements in the kitchen could increase the taste of meal components compared to traditionally produced food and increase the

variety of vegetable products offered without adding time-consuming tasks to production routines.

4.2 Meal elements in relation to Hypothesis 1

The first hypothesis of this thesis is “The quality of foodservice meals can be improved by use of meal elements”.

Conditions of the field study

It was chosen to involve foodservice professionals in the test of this hypothesis on the following reasons: Foodservice professionals have the responsibility of preparing foods in institutional kitchens and make the decisions on choice of foodservice concept and ingredients. This means that the possibilities for applying meal elements in institutional foodservice and testing the quality of meals prepared rely on the professionals’ acceptance of the products. Therefore the kitchen managers’ accept of meal elements is the important first step in the testing of the applicability of meal elements and in the testing of the hypothesis.

Testing of meal elements required the existence of these products. Pre-fried meat and vegetables were chosen as it was possible to produce products with the desired characteristics using the frying equipment in pilot plant at DTU.

Improvement of meal quality at Rygårds Centret

The findings showed that pre-fried meal elements had increased or improved sensory quality compared to most of the products they in theory should substitute. This was mainly meat and vegetables in casseroles where the existing procedure was boiling of components without initial browning or frying. The choice of procedure showed that the kitchen managers had given up the browning procedure and accepted that it was not possible to achieve the desired output quality. However, as heat and humidity during heat

treatment of meat is important for the formation of taste, too low temperature or too much water present will deteriorate the taste intensity of products (Meinert *et al.*, 2007), (Bejerholm and Aaslyng, 2003). This implies that boiled meat have a less intense taste compared to fried meat. In pilot plant conditions were more optimal for the formation of flavour compounds. The meal elements in the test were assessed to have increased taste compared to the cooked products. Considering this it is much likely that pre-fried meal elements would increase the taste of meals produced. This was one of the main arguments for using meal elements put forward in the meal element concept.

The elements should also substitute the browning process in the preparation of single portioned meat pieces. The browning process took up long time in production and homogenous product quality was difficult to obtain. As fried meat or fish were frequent components of dishes on the menu the quality of existing products must have been generally accepted in the kitchen. In this case substituting existing products with meal elements would not automatically increase the quality of meals. Instead using meal elements in production could offer the possibility to relocate resources from the frying process to tasks of more importance for the users' experience of meal quality. Examples of such tasks are baking of bread or carefully controlling production parameters of other processes which have shown to be important for the users' perception of meal quality. This way applying pre-fried meal elements as a mean to optimize the use of resources would theoretically lead to improved quality of meals. The re-allocation of resources in order to improve meal quality was part of the systemwise approach to meal production in the meal element concept.

Limitations on the findings

In the test the quality of pre-fried meal elements were evaluated separately, not as components of ready-to-serve meals. However, following this

procedure no conclusions on actual meal quality could be made. The findings though may indicate the applicability of meal elements in foodservice meals.

The evaluation was done by foodservice professionals and did not include the end-users' opinion on eating quality of meal elements. It would be necessary to include this in further testing before concluding on quality of meals made from meal elements.

Finally, it is worth stressing that the conclusions on this testing concern only the acceptance of pre-fried meal elements and that a general conclusion on the acceptability of meal elements could not be drawn.

4.2.1 Conclusion on Hypothesis 1

From the findings in the test Hypothesis 1 "The quality of foodservice meals can be improved by use of meal elements" is accepted.

4.3 Findings from the Lean manuscript

The purposes of the Lean manuscript were to discuss the theoretic application of Lean in foodservice production and to describe a field study of the implementation in the foodservice at a hospital. Lean was implemented in the kitchen as a tool to rationalize procedures and increase efficiency of the foodservice system. The process of implementing Lean followed a change in operational system from cook-serve to cook-chill and a reduction in the number of employees. This change made it necessary to optimize procedures to produce the needed amount of food of required quality and within the chosen time schedules. The findings showed that the results achieved so far were increased efficiency of production procedures, measured as a reduction of product waste, and a reduction in working over-time in the kitchen. They also showed a reduction in number of complaints on meal quality as the result of systematic evaluation of meal quality.

4.4 Lean in relation to Hypothesis 2

The second hypothesis of the thesis is “Lean Manufacturing can be applied in large scale foodservice and lead to increased product quality”.

Conditions of the field study

Hypothesis 2 was tested by studying the effects of Lean in the hospital kitchen at Glostrup Hospital. The kitchen had recently gone through some major changes as the cook-serve system had been substituted with cook-chill and the number of employees reduced. This caused special conditions for the implementation of Lean as the “normal” procedure would be a reduction in the number of staff as a consequence of Lean procedures. In the central kitchen the production system was changed and staff reduced prior to implementing Lean. The purpose of applying Lean in this situation was to optimize procedures in order to maintain production performance with fewer employees and to reduce the amount of overtime accumulated among kitchen staff which caused a general discontent.

During the implementation of Lean the manager had a special purpose of maintaining a pleasant working environment in the kitchen. This is not a common goal of a rationalization process and Lean as a production principle has been criticized for causing monotony of working tasks and deterioration of working environment in industrial productions (Hansen, 2006). On the other hand Lean could also lead to improved working environment provided that the management actively use the Lean tools to involve workers in process performance (Hansen, 2006).

In the central kitchen the manager’s specific requirement for focus on the working environment distances the case from the “common” Lean implementation. Still, the case shows how Lean could be applied in meal production. When the field study began Lean had already been implemented in some parts of the production system and the initial effects on production

procedures and product quality had shown. It is in this context that the effects of Lean on meal quality are discussed.

Improvement of meal quality at Glostrup Hospital

The findings showed that implementation of Lean resulted in increased efficiency of production procedures by reduction of product waste, improved organization of production wares, and improved organization of meal ingredients in storing facilities. Increased efficiency of procedures may not in itself have a positive effect on food quality. Organization of production tools and raw ingredients however, facilitates production procedures and is part of the systematization of procedures needed to achieve required quality of foods when producing large quantities. Hence, the initiatives taken on organizing equipment and ingredients may contribute to the improvement of food quality.

The establishment of an internal quality control system for meals improved quality of foods as it reduced the number of customer complaints on the food. The systematization of end-users' feedback on meal quality provided communication between kitchen and client which was argued to be an important factor of success for a foodservice system (Khan, 1991), (Jones and Merricks, 1997). The use of measurable parameters also provided the kitchen staff with benchmarks which made it easier to identify exactly why and how the foodservice should improve. Like the initiatives taken to increase organization of production line the quality control system or the use of measurable parameters in itself did not change meal quality. It was supplying the frame and the systematization of procedures which were needed to improve the quality of meals. This way using Lean tools improved the quality of meals produced in the kitchen.

Limitations on findings

The conditions of the field study were initially classified as being different from other rationalization processes. The main reasons for this statement were the order of rationalization of procedures and reduction in number of employees

as well as the focus on the working environment during the process. This will certainly influence the process of implementing Lean as it partly predetermines the effects of the change, e.g. procedures need to be optimized to a degree where the reduced number of staff can manage production within working hours. Lean may bring further perspectives for optimizing the production process which will not be discovered due to the preset goals of the process in the kitchen.

However, a Lean meal production will in any case be different from most other Lean production scenarios as the boundary conditions of meal production are specified by the perishable nature of foods. Of great importance is the influence of the parameters time and temperature on product quality which creates a need for controlling processes to avoid undesirable changes in product quality. This was exemplified by the implementation of Lean in the cold production area in the central kitchen as Lean principles had to bend to fulfill the requirements for product temperature. In the cold production area the result was that some wasteful activities were retained in production procedures to meet the temperature requirements.

Another characteristic of institutional foodservice which influences the implementation of Lean is the operational system in use. In the central kitchen the use of cook-chill implied that the Lean principle of minimizing storing of products and striving for just-in-time production was violated. The force of cook-chill systems is exactly the decoupling of meal production from serving hence it can never deliver just-in-time production as required in Lean. The implementation of Lean in a setting like this will have to show a pragmatic solution. These characteristics of “Lean meal production” were also discussed in the Lean manuscript in Chapter 3.

4.4.1 Conclusion on Hypothesis 2

From these findings Hypothesis 2 “Lean can be applied in institutional foodservice and lead to increased product quality” is accepted.

4.5 Meal elements and Lean: Two frameworks for institutional foodservice

In this passage the findings are discussed to clarify the applicability of the Meal elements concept and Lean in institutional foodservice.

4.5.1. Applicability of The concept of Meal elements in meal production

The concept prescribes that meal elements are convenience products of superior quality to conventional convenience products and that they are made to fit the special conditions of foodservice production. Using meal elements in production the variety and quality of meals produced can be increased with only little use of time and limited further processing.

The findings from the test supported the concept so far that the quality of most pre-fried meat and vegetables was acceptable to the kitchen professionals and that pre-fried vegetables were distinct different from both traditionally prepared vegetables and conventional convenience vegetable products. From this it was concluded that the variation of vegetable products prepared in the kitchen could be increased by meal elements. It is a question of preference and of specific needs and requirements for product attributes if the quality of meal elements is regarded as superior to the quality of conventional convenience products. However, as meal elements are prepared for a specific use it is most possible that they will improve the quality of meals which alternatively are made from conventional convenience products.

The test did not include evaluation of actual meal quality and therefore no conclusion can be made on the quality of meals assembled (partly) from meal elements. This is to be included in further research on the topic.

The most difficult part of the concept showed to be the coordination of the quality of pre-fried meal elements and the specific requirements for product quality set by the kitchen. The coordination is part of the concept's systemwise approach to foodservice meal production argued to be important to achieve the required culinary quality of products. The test showed that this part of the concept demands thorough knowledge of the kitchen's procedures and traditions for preparing meals in order to understand the specific requirements. It also showed that it was highly relevant to consider the requirements for products set by the conditions of application in order to optimise the applicability of meal elements. The influence of finishing processes on requirements for initial preparation of meal elements needs to be systematically uncovered in future work. Otherwise, it will be very difficult to produce meal elements of required quality.

The findings from the test also indicated that resources allocated to the task of frying meat could be reduced or re-allocated to other tasks in agreement with the concept. In this way the test proved that the consideration of meal elements as ingredients in a system of processes is applicable in institutional foodservice.

4.5.2 Applicability of Lean in meal production

In this research the aim was to discuss Lean as a tool to manage meal production and achieve increased control of process parameters with the overall aim of improving meal quality. The findings of the Lean manuscript showed that the Lean tools 5S, value stream mapping and "Blitz Kaizen" events caused the rethinking and systematization of procedures needed to achieve increased efficiency of production. The establishment of measurable parameters to express customer satisfaction and the systematic evaluation of recipes provided the tools to improve meal quality. These findings are in agreement with the theoretic outcomes of implementing Lean in industrial productions (Womack and Jones, 2003). From this it was concluded that Lean

showed positive results as a tool to manage meal production and organize procedures in production facilities. To produce meals of high quality process parameters still need to be strictly controlled and procedures for this must be an integrated part of the system. So far, the field study showed no results on this subject and it could not be concluded if Lean could lead to improved control of process parameters. The reason may be that the process of implementing Lean was still in the phase of increasing performance of the system by reducing waste. Increasing performance of production by control of process parameters during production and distribution may be a future goal to achieve in the process of further implementation of Lean in the central kitchen. Proper control of process parameters is indeed central in Lean since lack of control will increase the possible waste from a process in terms of time, energy and product.

The success of managing meal production with Lean is possibly caused by the focusing on end-users' satisfaction with product quality. Jones and Merricks state that the conventional management approach is to map the flow of raw materials through the system without considering the eventual customer (Jones and Merricks, 1997). This leaves the important feedback loop on customer satisfaction unnoticed. In Lean theory the customers' preferences must continuously be the basis for selection and review of procedures with the purpose of optimizing customer perceived product value. However, to define value can be very difficult in institutional foodservice as the end-users are a non-homogeneous group of clients with varying preferences. A condition like this makes it indeed important to collect information on end-users' requirements on a routine basis and to continuously adjust quality and type of meals served in agreement with the information.

The continuous measuring of customers' satisfaction with meal quality in the kitchen at Glostrup Hospital as well as the kitchen's internal system for quality evaluation of meals produced resulted from Lean procedures. Both systems showed the advantages of expressing progress of processes by measureable parameters and that Lean supplied the tools to collect the data needed.

Communication between kitchen and customer was stated to be the fourth part of foodservice systems and decisive for the successful transformation of inputs to outputs in food processes (Jones and Merricks, 1997). In this way, Lean in the Central kitchen at Glostrup Hospital adopts the “foodservice systems approach” argued to be essential for successful foodservice and necessary in order to satisfy the clients of institutional foodservices.

4.6 Applicability of findings in institutional foodservice concepts

The purpose of this final part of the discussion is to relate the findings of the two frameworks to the design of foodservice concepts.

According to the foodservice management theory there are mainly three reasons why foodservice concepts perform badly; improper design of concept, inadequate match of operational system and concept, and management failing to meet expectations (Jones and Merricks, 1997). These three aspects will therefore be considered in the discussion of how the findings can be applied in foodservice concepts.

4.6.1 Discussion

The design of foodservice concepts includes choosing inputs and processes and combining them to meet customers’ demands for outputs. The inputs, processes and outputs function together in a system and changing one of the parameters influence on the performance of the system (Khan, 1991). In institutional foodservice this means that ingredients and processes must be chosen so that users’ requirements for meal quality can be met with the operational system in use. To achieve this on a daily basis management of processes is needed as well as consumers’ feedback on product quality (Jones and Merricks, 1997).

The findings from the research on meal elements showed that these products can be used in foodservice production and that they have the robust nature required to maintain quality in the existing operational systems. From this it is concluded that meal elements offer a choice of “new” ingredients needed to produce high quality meals within the operational systems of most institutional foodservices. Meal elements supply the ingredient part of a concept where meals are assembled and reheated with limited processes. This could be in satellite kitchens or in large production units where use of man hours need to be reduced or required product quality cannot be produced. To meet customers’ demand for output recipes and composition of meals need to be revised when ingredients are changed from conventional products to meal elements. This part of foodservice concepts has not been considered in this research.

Management of foodservice systems is important to coordinate procedures and make the subsystems function together as well as achieving the required feedback from customers’ on product satisfaction which is essential for a successful foodservice system (Jones and Merricks, 1997).

Lean showed positive results on managing food production processes in the central kitchen at Glostrup Hospital. From the findings of the field study it was concluded that Lean tools can be applied in institutional foodservice kitchens and result in a more organized and efficient production process. It also provided the feedback system on customer satisfaction which is decisive to continuously fulfil customers’ demands for product quality. In this way Lean supplies some of the tools needed to manage foodservice operations. These tools may prove especially useful in future institutional foodservice as the next generation of clients will expect a much higher standard of service than today’s average user.

From the findings it is concluded that both frameworks; the concept of meal elements and Lean in production can be applied in institutional foodservice

but that the application of both frameworks need to be further explored. It also seems that the frameworks supplement each other well as each supply important inputs to the design of foodservice concepts. The possible advantages of merging the two frameworks into one concept have not been included in this research but will be relevant to include in future research on design of institutional foodservice concepts.

Chapter 5: Conclusion and perspectives

5 Conclusion and perspectives

This final chapter includes the conclusions on the hypotheses and perspectives for future research to supplement the findings of this research.

5.1 Conclusion

In this thesis possibilities for improving the quality of meals produced in institutional foodservice were explored using two frameworks 1) The concept of Meal elements and 2) application of Lean in production. Two hypothesis were put forward to explore and discuss the frameworks, namely Hypothesis 1 “The quality of foodservice meals can be improved by use of meal elements” and Hypothesis 2 “Lean can be applied in institutional foodservice and lead to increased product quality”.

The applicability of meal elements was tested in the kitchen at a nursing home and it was found that the quality of pre-fried meat and vegetable products were generally acceptable to the kitchen managers. The findings also indicated that pre-fried meat could enhance the taste of meals and that using pre-fried vegetables in the kitchen would increase the variety of vegetable products prepared. From the findings it was concluded that meal elements can improve the quality of institutional foodservice meals and Hypothesis 1 was therefore accepted.

The second hypothesis was tested by studying the practical implementation of Lean in a central kitchen at a hospital. The study showed that Lean improved the efficiency and organization of the meal production and that Lean brought the systematization of feed-back and quality control procedures needed to improve meal quality. In the light of this Hypothesis 2 was also accepted.

5.2 Perspectives

The findings of this research showed that meal elements and Lean can be applied in institutional foodservice and lead to improved quality of meals. As the conclusion is based on only two cases further research on the topics is necessary before drawing general conclusions. For meal elements this includes more testing on the applicability of pre-fried meal elements and development of meals and recipes in agreement with the characteristics of the pre-fried ingredients. It would also be interesting to develop other varieties of meal elements, e.g. fish products or base sauces to extend the knowledge on the practicable application of the concept. It would also be interesting to include end-users in the evaluation of the eating quality of meal elements.

It would be interesting to study further the application of Lean in more kitchens and to observe if Lean meal production would show different results in other kitchens. Especially when this involved implementation of Lean in neutral foodservice settings where pre-set goals were not part of the conditions. Future perspectives could also focus on the possibilities for increasing control with production parameters in meal production.

Finally, it would be very interesting to combine the findings of the two frameworks into one foodservice concept where meals were to be assembled from meal elements and the production and distribution chain were managed with Lean principles. Theoretically this would bring a solution to the problem of efficiently delivering high quality meals within the frames set by the operational systems in institutional foodservice.

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Appendices

A: Case studies

B: Technology trends paper

Appendix A: Case studies of institutional foodservice systems

A.1 Introduction

Case studies of seven foodservice systems were part of the initial activities of the project. The studies had three purposes; to learn about the planning, cooking, and distribution procedures of typical foodservice systems, to identify eventual problematic procedures in the individual systems, and to identify requirements for convenience products in the individual systems. The latter was important to develop meal elements (Chapter 2) for institutional foodservice use.

This appendix provides an overview of the seven foodservice kitchens studied. The findings from the analyses of the cases have already been presented in Chapter 1 of the thesis.

A.2 Methodology

Two procedures were followed in the case studies:

1. Kitchen managers were interviewed for 2-3 hours including a guided tour in the production facilities. The managers told about the production processes in use, the number of meals produced, the number of employees etc. They also told why particular production systems had been chosen and the advantages and limitations it brought to the required production of meals. An interview guide was prepared in advance but only briefly consulted during the interviews. The larger part of the interviews had the form of an informal dialogue. This procedure was applied in two of the case studies, a hospital's central kitchen (Ribe) and a central production unit (Svendborg).
2. The remaining five kitchens were visited for two-three whole days during which the production procedures were observed. The first morning I introduced staff to the purpose of the visit. They were

informed that I would observe their work to learn about the production procedures. Staff was invited to comment on existing routines and procedures and to explain if they found any procedures particular inoptimal or well planned. Informal interviews (small-talk) with staff were used to collect additional data on routines and production systems.

The outputs of these four case studies were written reports on the observations including suggestions of which conventional produced products to substitute by high quality convenience products in order to improve over-all meal quality.

A. 3 Foodservice systems in use

In Table A data describing the production settings and systems is shown. As some information on the case studies is included in the introduction the data in Table A is supplementary.

A. 4 Results

The studied kitchens varied much in type, number of meals produced and operational systems in use. Convenience products were used in all kitchens though the kitchen manager in Ribe was the only one who systematically had compared conventional and convenience products and calculated how ressources were best utilized.

The observations showed that base sauces, potato products and desserts were potential meal elements. Almost all kitchens had substituted their original “home-made” products with convenience products (powders and bouillons and vacuum packed peeled potatoes) though the quality was just acceptable.

Table A: Foodservice systems in studied kitchens

Location	Type	Operational system	Number of meals	Distribution system	Comments
Ribe	Hospital	Cook-chill with modified atmosphere packing	1400 (patients+ kitchens at other locations)	Carrier service + hospital orderlies	Efficient. Many convenience products. Satellite kitchens at wards
Svendborg	CPU ¹	Cook-chill with modified atmosphere packing	500 meal days ² + 600 meals ³ + school lunches	Carrier service	Efficient. Staff supports all parts of production + maintenance of equipment. 57 dishes made every week.
Aktiv Centret	CPU	Cook-chill	4-500	Carrier service	Extremely complex, noisy and stressful production. Bottlenecks in packing
Rosenlund	Nursing home	Cook-serve	25 meal days+ school lunches (60-70) and 5-60 meals	Kitchen staff distributes meals	Just-in-time production. Teamwork and nice atmosphere Bottlenecks in production
Toftebo	Nursing home	Cook-serve/cook-chill	65 meal days + 60 meals	Kitchen staff distributes meals	Residents can prepare meals or snacks in satellite kitchens.
Holstebro	Hospital	Cook-serve	600 meal days	Hospital orderlies	Production is just-in-time but the distribution system delayed the serving of meals. Bottlenecks
Herlev	Hospital	Cook-chill	850 meal days	Hospital orderlies	Little organized production area, cook-chill as a safety net. Bottlenecks

¹CPU: Central Production Unit²Meal day: 3 full servings and 3 light meals (morning, afternoon and evening)³Meals: Meals served from cafés located in connection with the kitchen. Numbers may be varying with the activities planned for the particular day.

A. 5 Additional observations

The observations showed that exact control of process parameters were routine only when heat treatment included use of ovens, e.g. in the preparation of roasts. In these cases a stop watch was used to control process time and a thermometer to measure product temperature. The purpose though was not to optimize product quality but to keep temperature requirements as set by the quality control programme. In all other cases cooking of products was finished when the individual employee evaluated the products as “done”. This often caused foods to be extremely well done (especially meat) and in one case the kitchen staff even commented on the quality of meat as being “dead” after initial heat treatment. In that particular foodservice system the meat still had to be chilled, stored, reheated and distributed before being served.

Bottlenecks occurred frequently during most productions. The exceptions were Ribe and Svendborg which were extremely efficient cook-chill systems, designed and planned by the same person, and a smaller kitchen at Toftebo. In all other kitchens bottlenecks occurred though much effort was put into spreading production tasks over the week days in order to level the work load. The levelling of production tasks included starting up production of food at one day and finishing the food one of the following days when food products allowed this procedure. The levelling of production tasks though was not done to a detail where time schedules and booking of equipment was used. At the contrary the production tasks were performed in the order preferred by staff. A result of the insufficient planning was food queuing up to be processed at equipment with limited capacity.

Distribution of meals was rarely considered part of the production system as it was often outsourced or taken care of by other groups of personel. This could

influence on meal quality in cook-serve systems as external factors could hinder and cause delays in the distribution of warm meals. In one kitchen this had caused the employment of a dietitian with responsibility for coordinating the production, distribution and serving of meals into one system.

The separation of production, distribution and serving also hindered dialogue between kitchen and customers which made it difficult to systematically collect data on customers' satisfaction with meal quality.

Appendix B: Technology trends paper

Title: The modernization of hospital food service - findings from a longitudinal study of technology trends in Danish hospitals

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The modernization of hospital food service – findings from a longitudinal study of technology trends in Danish hospitals

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Abstract

Purpose – Hospital food has come into focus during the last decade due to reports of under-nutrition and at the same time food service has undergone significant changes. The aim of this paper is to document and discuss the change in technology and logistics used in the Danish hospital food service during the years 1995-2003. Further, the aim is to discuss possibilities for integrating food production and patient nutrition at hospitals in order to improve patient nutrition.

Design/methodology/approach – The empirical data consist of quantitative serial data on Danish hospital food service collected over a period starting in 1995 and ending in 2003. Data have been collected as part of two large surveys describing the food service systems in Danish hospitals in 1995 and in 2003. Both surveys were carried out by the Food Research Department of the Danish Food Authorities. Answers were compared by means of Chi-square (χ^2) tests with Yates' correction. Two-sided *p*-values <0.05 were considered significant.

Findings – There have been significant changes in food production systems during the years 1995-2003. A change in employee profiles in the kitchens has followed this trend.

Practical implications – Plating systems have changed as well with a higher use of buffets and satellite kitchens and less use of central plating during the period 1995-2003. The educational background of employees has also changed resulting in an increase in number of skilled employees (cooks, catering assistants) and fewer unskilled employees in the kitchens. Increased focus on nutritional status of patients has been observed from ward personnel with no connection to the kitchen. It is suggested that food ambassadors be responsible for the nutritional status of patients.

Originality/value – Success in explaining technological and logistical changes in Danish hospital food service 1995-2003 another integration of food production and patient nutrition in hospitals.

Keywords Food safety, Hospitals, Technology led strategy

Paper type Research paper

Introduction

There is an increasing awareness of the cost of public service provision and during the New Public Management (NPM) era in the last two decades much effort has been devoted to developing more cost-effective forms of such provision (Hood, 1991; Walsh, 1995). NPM has introduced new styles and patterns of public service management and service provision, which has affected the cost of the catering sector, including hospital food service, significantly. The continuous requirement for reducing costs has led to increased interest in the use of more industrial type technologies, i.e. sous-vide, cook-chill and modified atmosphere packaging in the food service (Danish Catering Centre, 1995).



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These technologies offer a longer shelf life of product and give the possibility of reducing manpower needs (Clark, 1997). Outsourcing, labour cuts, extensive use of brokers and new production layouts are among other significant denominators of this development (Creed, 2001; Danish Catering Centre, 1995).

At the time NPM affected the hospital food sector significantly, an increased interest in hospital food and nutrition evolved, since insufficient energy intake is a substantial problem among patients in European hospitals (Beck *et al.*, 2003). A number of studies have shown that poor appetite, low food intake and under-nutrition are frequent among hospital patients (Green, 1999; Beck *et al.*, 2003; Council of Europe, 2001; Bates *et al.*, 2002; O'Flynn *et al.*, 2005). However, while NPM in the hospital food sector has evolved in the areas of technology and production, the increased interest in nutrition has evolved primarily with the ward and patient as a focal point. Where the NPM has been driven by town-hall bureaucrats and administrators the increased interest in nutrition has been primarily driven by an increased interest from medical doctors and dieticians.

We choose to term these two trends related to technology and nutrition in institutional hospital food service the modernization of hospital food service. The question is whether these two different trends in the modernization are competing or are they two sides of the same coin? Do they pull in the same direction and, if not, can we bring them to do so? Do we need to understand hospital food and nutrition as an overarching network involving technology, food and kitchen as well as nutrition, patient and ward? Do we, instead of examining small pieces of the systems as a traditional reductionist approach, suggest needs to rethink and apply an overall network approach to be able to govern the hospital food and nutrition network? Assembling the different parts of the system in a more systematic way may result in better nutritional care for the patient.

The aim of this paper is to identify the features of the modernization – the significant changes that have occurred in hospital food service over the past decade with regard to technology and logistics. This development and its nutritional implications will be discussed as well as the perspectives of applying a whole systems approach to hospital food service and nutrition rather than the perspectives of a reductionist.

Methodology

The empirical data consist of quantitative serial data on Danish hospital food service collected over a period starting in 1995 and ending in 2003. Data include technology in use, production configuration, logistic of meal plating and educational background of employees and has been collected as part of two large surveys describing the food service systems in Danish hospitals in 1995 and in 2003. Both surveys were performed by the Food Research Department of the Danish Food Authorities.

The 1995 survey aimed at describing the different public food service sectors in Denmark (Udvalget om offentlig kostforplejning, 1997). A questionnaire was mailed to local authorities and from there distributed to the daily managers of large-scale kitchens in the county. A total of 95 questionnaires were sent out (Udvalget om offentlig kostforplejning, 1997) and 74 (78 per cent) completed questionnaires were returned and included in the survey.

The 2003 survey was a part of a study of public food services in both Denmark and Sweden (Mikkelsen *et al.*, 2004) but only the nationwide data from Denmark was included in the current study. Data include questionnaires mailed to Danish hospital kitchens addressed to the daily manager. A total of 93 questionnaires were sent out, of

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which 45 (48 per cent) were returned and included in the survey. The design of the questionnaire in the latter survey was inspired by the 1995 questionnaire to ensure the best comparability among the data.

Incomplete responses from both surveys have been eliminated from the data set. The prevalence of answers to the questionnaires in 1995 and 2003, respectively, were compared by means of Chi-square (χ^2) tests with Yates' correction. Two-sided p -values <0.05 were considered significant.

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Results

Table I shows the use of different technologies in Danish hospital kitchens in 1995 and in 2003. The table shows the distribution of the most common production systems; cook-hold and cook-chill used solely or cook-chill combined with other production systems.

The data demonstrate a significant increase, from 12 per cent to 29 per cent, in the use of exclusively cook-chill as food production system over the two time periods. This increase seems to be at the expense of the use of cook-hold (decreased from 52 per cent to 36 per cent not significant), while the amount of hospital kitchens using cook-chill in combination with other systems has been almost constant in the period.

During the same period the number of kitchens receiving chilled food from central production kitchens has increased significantly from 1 per cent to 20 per cent ($p < 0.01$) (Table II).

Table III shows the logistics of meal plating in the hospitals. In 1995 the majority of kitchens reported to have used a combination of centralized plating and decentralized plating/buffet style (58 per cent), while in 2003 significantly more kitchens reported to use only decentralized plating/buffets (31 per cent and 65 per cent in 1995 and 2003, respectively; $p < 0.001$). However, the total percentage using decentralized plating/

Table I.
Technology in use

Food production system	Hospitals (%)		
	1995 $n = 74$	2003 $n = 45$	
Cook-hold ^a	52	36	n.s.
Cook-chill ^b	12	29	$p < 0.05$
Combinations with cook-chill ^c	31	27	n.s.
Other systems	4	9	n.s.

Notes: ^aCook-hold: The food is cooked and held warm until serving; ^bCook-chill: The food is cooked, immediately chilled and held cold until reheating and serving; ^cIncludes cook-chill/cook-hold; cook-chill/cook-hold/modified atmosphere packaging; cook-chill/cook-freeze; cook-chill/cook-hold/cook-freeze

Table II.

Production configuration

	Hospitals (%)		
	1995 $n = 71$	2003 $n = 44$	
Central production unit	99	80	$p < 0.01$
Satellite kitchen ^a	1	20	$p < 0.01$

Notes: ^aReceiving chilled food from central production units

buffet alone or a mix of systems was constant throughout the years (89 per cent). In the 2003 survey, kitchens using buffet style food service were asked whether the buffets were manned by professionals. A total of 35 per cent answered fully or partly (data not shown).

Table IV shows that the number of employees with an educational background as administrative or clinical dieticians has stayed constant throughout the period, while the number of skilled employees with an educational background as cooks or catering assistants had increased significantly. The increase in number of skilled staff is mirrored in a decrease in the unskilled staff to nearly half.

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Discussion

The current study of technological and organizational characteristics in Danish hospital food service shows that significant change has taken place over the past decade with regard to technology, production configuration, meal plating and educational background of employees. The results show an increased use of longer shelf life technology (more cook-chill technology, less cook-hold), more decentralized plating (less central plating and more decentralized/buffets), as well as more decentralized handling (more satellites and less purely central layouts) and an increase in the number of skilled staff. This includes an increase of the number of cooks, indicative that hospitals are now placing more emphasis on culinary aspect of hospital food.

In this paper we will discuss the findings focusing on three different aspects, the production facility, the point of serve and the link between the two. The discussion will include how the advantages of the modernization, containing both rationalization components (NPM) and nutrition/patient-oriented components can be further enhanced and how the drawbacks can be challenged. Finally, we aim at discussing if the kitchen-to-ward supply chain can be tied more closely together applying a network perspective in which bit production and point of serve and the interlink between those is taken into account.

Plating location	Hospitals (%)			
	1995 <i>n</i> = 72	2003 <i>n</i> = 45		
Centralized plating	10	11	n.s.	Table III. Logistics of meal plating
Decentralized plating or buffet	31	65	<i>p</i> < 0.001	
Combination of centralized and decentralized plating/buffet	58	24	<i>p</i> < 0.001	

Education	Hospitals (%)			
	1995 <i>n</i> = 74 ^a	2003 <i>n</i> = 44 ^b		
Administrative dieticians	18	16	n.s.	Table IV. Educational background of employees
Clinical dieticians	3	3	n.s.	
Cooks	1	3	<i>p</i> < 0.001	
Catering assistants	28	48	<i>p</i> < 0.001	
Other skilled	5	6	n.s.	
Unskilled	45	25	<i>p</i> < 0.001	

Notes: ^aTotal number employed: 2,573 persons; ^bTotal number employed: 1,033 persons

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37,2*The production facility: more cook-chill technology at the kitchen side*

Our findings of an increase in use of cook-chill technology and less use of cook-hold correspond to its development in other countries. Mibey and Williams (2002) found that the number of Australian kitchens using cook-chill had increased from 18 per cent in 1993 to 42 per cent in 2001. An older British study also reports a movement towards cook-chill production among British hospital kitchens (Hwang *et al.*, 1999).

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A number of authors have studied the cook-chill technology (Light and Walker, 1990) and, in general, the cook-chill system is regarded as efficient and suitable for large-scale food production as it allows to produce more dishes (McClelland and Williams, 2003). Reports on the extraordinary advantages that cook-chill systems offer, such as saving millions of dollars (Anonymous, 2001) and improving productivity (Clark, 1997) tend to back up this understanding. As argued by Light and Walker (1990) cook-chill catering divorces production from service and consumption and is more efficient in staff and equipment usage. In this way longer shelf life technologies seem to free resources in production and provide more time for the optimal use of specialist staff skills.

Still, cook-chill catering is not a cure-all. As pointed out by Light and Walker (1990), cook-chill cannot produce high quality foods of all sorts. Some menu items are simply not suited to the method. Furthermore, vitamin losses can be substantial depending on the processing techniques and handling practices (Lassen *et al.*, 2002). These mean that more attention has to be paid to the menu planning and food activities when using cook-chill prepared food items in the menus.

Point of serve: more front cooking at point of serve

The results show an increase in decentralized plating with less central plating and more use of buffets and satellite kitchens. Decentralization emphasizes the importance of the point of serve. This brings more attention to the dining situation, the importance of which has been discussed by several authors. Barton *et al.* (2000) and Ödlund *et al.* (2003) found that a patient-oriented improvement in hospital food increased intake and decreased wastage. Kofod and Birkemose (2004) have shown the importance of the dining environment in food service settings at nursing homes and Gustaffson (2004) underlines the essential function of the dining situation as a part of a satisfactory meal experience. Meiselman (2003) too found that product, person and eating environment influence the acceptability of food served and Hartwell *et al.* (2005) argue that the opportunity to sit and eat a meal in company is often regarded as socially positive, especially by visitors. Kondrup (2002) found that among a number of initiatives that could contribute to improving nutritional intake for hospital patients, ensuring good service and ambience at mealtimes were very important, especially for patients with reduced appetite.

All of these results point in the direction that a successful food service includes much more than the production and distribution of food. The dining surroundings, the company and the atmosphere are as important as the quality of food served. The observed change in point of serve may indicate that the Danish hospital food service is now focusing more on the meal experience than previously. The increased use of buffets and satellite kitchens allow for more opportunities to give the patients a meal experience than traditional central plating does. Taking this point of view, the two trends in “modernization” seem to work together as the change in technologies support the increased focus on patient nutrition. It is worrying, however, that only a minor part of the buffets at the hospitals appears to be manned with professionals.

Further improvements of the situation would be to develop more user-friendly interfaces between point-of-serve and the patient and to develop a sense of food preparation close to the patients, so-called front cooking. Decentralized food “events” could be an option (Hartwell and Edwards, 2003) since taste and smell of food production are central to most patients.

As pointed out by several authors, problems with inadequate intake for hospital patients are closely related to inadequate meal choices and/or inadequate taste of the food served (Dupertuis *et al.*, 2003). Stanga *et al.* (2003) found that about 25 per cent of a random sample of hospital patients from various units ate nothing or very little in the hospital. In an Australian survey, Mibey and Williams (2002) did not find that the change in the food production system caused a change in the meal plating system. However, on the basis of the same study it was noticed that cook-chill services in hospitals offered more choices for the midday meal and more snacks during the day (McClelland and Williams, 2003). More choices are seen as improved quality of food service, especially for long-stay patients (Watters *et al.*, 2003).

One alternative to the plated system, the bulk trolley system, offers the patients a choice of menus although it does not offer the possibility to assemble one's own plate (Hartwell and Edwards, 2001; Edwards *et al.*, 2000). O'Flynn *et al.* (2005) found that altering the catering service from pre plated to bulk contributed to increasing intake and Wilson *et al.* (2000) demonstrated that bulk service increased patients' energy and nutrient intake and reduced food wastage compared to the plated system. This trolley system is different from the decentralized Danish buffet system although both offer a higher degree of choices in meals. Differences in preferred systems depend on the cultural differences of the countries.

These observations seem to support the suggestion that cook-chill technology and the like can have a positive influence on the nutritional status of the patients. The cook-chill systems can offer more menus and a more user-oriented finishing and serving of meals because it is often distributed using buffets or trolleys.

Link between kitchen and point of serve: longer distance but closer links between point of serve and kitchen

In modern large-scale institutions distance has increased between point of production and point of serve. One consequence of distance has been studied by Réglier-Poupet *et al.* (2005), who found that the total duration of the transport of food in hospital food service was ranged from 44 to 123 minutes and that this, in most cases, resulted in meals not meeting the official temperature requirements.

An important issue, therefore, is to strengthen the links between food service production and point of serving – in other words, the link between the ward and the kitchen. This is especially important since our results show that food service has been centralized and the distance from kitchen to ward has increased. The stretching of the food chain may influence the quality negatively and increase the need for securing food safety (Hartwell and Edwards, 2001) but the increased distance also makes it difficult to adapt to patients' demands. Hartwell *et al.* (2005) found that a common theme among patients was their inability and difficulty in providing feedback to the catering staff. The perception was that food was prepared some distance away by anonymous people who rarely came to the ward. The view that there seems to be a missing link between ward and production is supported by Lassen *et al.* (2006). The authors found that about 80 per cent of medical in-patients found meals to be very important but that they lacked information about the food service. Lassen *et al.* (2006) further found that the

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nursing staffs were exercising a “knowledge monopoly” in relation to the food service. In conclusion, a majority of the patients did not perceive nutritional care as part of the therapy and nursing care during their hospitalization (Lassen *et al.*, 2006).

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This lack of communication between ward and kitchen makes it difficult to adjust the menus to patients’ demands. Also, the lack of communication with end-users may result in reduced quality of food produced in the kitchen. These problems indicate that a meal service system based on cook-chill needs more attention than a traditional food service system. Hartwell *et al.* (2005) suggest that a manager is required to orchestrate the process within the hospital environment. The manager should have responsibility for the entire process from kitchen to consumption, and a position at board level. The use of a manager or food ambassador may ensure a more optimized distribution system with focus on gathering feedback from the patients. In general, they should bear responsibility for the link between the kitchen, the ward and the patient and focus on the shortening of distribution from kitchen to wards. Responsibilities of the food ambassador should also include monitoring the quality of food served and ensuring manning of buffets by professionals.

This is in line with Almdal *et al.* (2003) and Watters *et al.* (2003), who argue that catering at hospitals should be reorganized so that specific staff members are given the responsibility as well as adequate training and authority in the area. What we suggest is that the production, distribution and serving of food as well as the nutritional status of patients are viewed as one process with one (or a small group) of person(s) being responsible for optimization of the chain. This holistic view of food service in hospitals is further discussed below.

Towards a holistic network view of hospital food and nutrition

According to the Council of Europe (2001) lack of clearly defined responsibilities has been identified in the management of nutritional care at hospitals together with fragmented co-operation among different staff groups. As argued by some authors, food service is only peripherally embedded in the hospital environment (Hartwell *et al.*, 2005). They argue that hospital food service should not operate in isolation but request the co-operation and integration of several disciplines to provide the ultimate patient experience. Food service management was found to be of a fragmentary nature which caused communication difficulties between kitchen and wards. Part of the problem is that caterers have to rely on kitchen porters for food delivery, ward staff have difficulty in communicating with caterers and dieticians/doctors are reliant on nurses to communicate any concern regarding patients. They conclude that a hospital food manager was essential to oversee the whole meal process from kitchen to consumption (Hartwell *et al.*, 2005).

We argue that increased synergy could be obtained through closer co-operation between ward, supplier and kitchen and linking staff (porters) and supporting staff (doctors, dieticians). Good hospital food requires more coherence among the different parts. This is what sociologists would call the need for more social capital. The social capital of this virtual system is clearly seriously challenged during outsourcing which, in the current study, has been demonstrated to be a significant trend. As pointed out by Wilson *et al.* (2001) outsourcing of catering in institutional food service has not been without problems. One apparent problem is that only the production is outsourced instead of the total system. Since we argue that hospital food should be regarded as a system, clearly outsourcing presents a challenge which must be addressed. As Halpern (2005) puts it, the glue that binds systems together intra organizationally tends to

dissolve when tasks are subcontracted. According to Hartwell *et al.* (2005) food service departments are usually seen as part of facilities rather than as an integral part of patient treatment with a trend towards contracting out. This emphasizes the requirement for a competent purchaser who can verbalise and describe what is required. The hospital management should acknowledge responsibility for food service and give priority to a food policy.

Therefore a rethinking is necessary. We must take an overall system view. Hospital food and nutrition is a complex system involving technology, food and kitchen as well as nutrition, patient and ward. Instead of examining small pieces of the system, as a traditional reductionist approach suggests, we need to rethink and apply an overall systems approach by assembling the two parts and thus being able to explain the whole.

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Conclusion

The focus on the costs of the public food service seems to have resulted in an increased use of cook-chill technology in the Danish hospital food service sector in the years from 1995-2003. This is connected to the observation of more satellite kitchens and a decrease in the number of central production units. Plating systems have changed as well with a higher use of buffets and satellite kitchens and lesser use of central plating. During the period the educational backgrounds of employees have also changed resulting in an increase in the number of skilled employees (cooks, catering assistants) in the kitchens. At the same time an increase in focus on nutritional status of patients has been seen during the period, though this interest seems to come from ward personnel with no connection to the kitchen. We call the two trends (increased use of technology like cook-chill in the kitchens and more focus on patient's nutritional status at wards) the modernization of the food service system.

We find that increased use of cook-chill technology may possibly result in more focus on the nutritional status of patients by offering more menus and buffet-style distribution. Still, the system could be improved further if the production, distribution and serving of food were viewed as closely connected to the nutritional status of patients. We suggest that food ambassadors be responsible for this by working solely on the integration of the chain and how to meet patients' requirements in order to improve the general nutritional status of patients.

Strength and weaknesses of the methodology

The response rate in the 2003 survey was much lower than in 1995. The probable reason for this is that the first survey was part of a bigger survey of the public food service in Denmark, which involved several ministries and political organizations and hence received a lot of focus and support. In contrast, the second survey had less attention. This might have biased our results. Still, our findings are in line with what has been reported in literature.

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